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OFFICIAL ORGAN OF
The Institute of British Foundrymen
The Institute of Vitreous Enamellers
The Welsh Engineers' and Founders' Association
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BRITISH CAST IRON RESEARCH ASSOCIATION
The Registered Office and Laboratories of the B.C.I.R.A. are:—
21-23, ST. PAUL'S SQUARE, BIRMINGHAM
Telephone: Colmore 4274-4275 Telegrams: CIRA
The B.C.I.R.A. Scottish Laboratories are:—
Foundry Technical Institute, Meek's Road, Falkirk
Telephone: 332

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Cost of Alloying

Dr. W. H. Hatfield, F.R.S., did a good service to the foundry industry, as well as to the special steel trade, when he stressed the real cost of alloying in his Presidential Address to the Sheffield Society of Engineers and Metallurgists. He pointed out that the arithmetical method of adding the cost of the added alloy to that of the unalloyed steel was a fallacy, because of the incidence of increased vigilance; metal losses; time of melting; of the extra effort needed for thorough fettling; of the meticulous care exercised during forging, rolling and heat-treatment; and finally of the heavy discards which may be involved. Many of these incidentals are acting with equal force on the specialised products of the foundry industry, plus the additional one of especial care to be exercised in the making of the mould. The steel foundry now makes quite a high percentage of alloyed steel castings, and their sale on the basis of the normal price of similar pieces plus the cost of the alloys used would quickly result in an adverse balance sheet. Extra expense is shown in almost every department—moulding, melting, fettling, heat-treatment and discard—as heavier runners and risers are usually called for. In the ironfoundry, much the same conditions are experienced when making high-duty irons, and especially heavy are the increased costs of moulding, as steel-foundry practice has to be emulated.

Recently, through the kindness of Mr. Marsden, of Joseph Stubbs, Limited, manufacturing details for the production of high-silicon acid-resisting irons have been disclosed in the JOURNAL. Here is a typical case which confounded the engineers' buyer. Just prior to the outbreak of the war, we were consulted on two occasions by Government officials as to why this high-silicon material commanded such a high price, as the arithmetical method of materials costing showed nothing very special. Our rather superficial knowledge was happily sufficient to satisfy the inquirers, but had we only known that the material was usually remelted three times, we should not only have been better armed, but without, we hope, being guilty of assuming superior metallurgical insight, we should have recommended, as does Mr. Marsden, the electric furnace, or at least a furnace other than the cupola, for its preparation.

Here, then is one of the drawbacks in the retention of processes as "secret," and perhaps, as a rider, one could postulate the advantage of branding a material under a trade-mark. As the buyer can scarcely be expected to appreciate the costs of manufacturing special-purpose cast irons, and as to him it is almost axiomatic that cast iron should be cheap, it is obviously good policy for the sales manager to bestow upon his material a brand name, excluding the words "cast iron." Meehanite metal and Ni-Resist are typical examples of such enterprise. In the former case the process is emphasised, and in the latter an alloy addition, to the exclusion of the base metal. Even when special materials become standardised by the B.S.I. or a Government buying authority, the goodwill of the trade-mark can be retained, as is done by the light-alloy founders, who in their trade literature usually correlate the specification numbers with their own trade brands. We do not remember having seen an analogous step taken by the ironfounders, yet since high-duty irons are now covered by B.S. and other specifications, such references could be usefully incorporated in publicity matter.

Ironfounders should be on their guard lest they fall into the trap of using special processes or alloying to overcome a current problem, without the full knowledge that the continuation of such practice must involve a higher sales price. Obviously, where such alloying or a special process has overcome a difficulty, the customer should be given the full facts and be notified that future orders will have to cover the expense of alloying or processing, plus the consequential costs. We are reasonably certain that this policy will be endorsed by the development departments of the great virgin metal organisations, as it is obviously better to create new and improved materials than ameliorates designed to overcome a passing difficulty.

High-Pressure Die-Casting of Aluminium

Experimental tests on the high-pressure die-casting of aluminium have indicated a definite improvement in the structure of the castings with increases in the injection pressures. Also, the injection of aluminium in a slush or plastic form reduces the time required to solidify the casting in the mould and also produces a solid casting.

A machine has been developed by the Lester Engineering Company and built by the Phoenix Machine Company, Cleveland, capable of die-casting aluminium melted to a slush form, at injection pressures ranging from 5 to 10 tons per sq. in., and of sufficient capacity to produce castings of 2 and 3.3 lbs. per shot. The aluminium is taken from a crucible by means of a crucible-ladle, directly into the ported hardened-steel injection cylinder.

Injection is accomplished by a hydraulic system of sufficient capacity and pressure to supply the constant high injection pressure required. The total pressures used, also the total volume or rate of injection movement, can be controlled independently of each other, if desired. The injection plunger and the hydraulic cylinder packing gland are water-cooled.

Locking the Die Parts

The two halves of the die or mould are held into positive close contact to withstand separation by the injection pressure, thus preventing the formation of flash on the casting. This is accomplished by the application of a double toggle link mechanism, which is actuated by a hydraulically operated piston; a locking pressure of 600 tons is developed. The stress of the shock load resulting from the metal injection at high pressure is not applied to the toggle pins but is transmitted directly into the U frame. When the two toggle links are in the closed position, cam faces located at each end of each toggle contact and are aligned with like cam faces on the movable plate and on the frame; the shock load is thereby transferred through each toggle link without applying further stress to the toggle pins.

What is Cast Iron?

In the Bulletin of the British Cast Iron Research Association, MR. J. G. PEARCE reopens the question of defining cast iron. After minor suggestions for amending Norbury's definition, the author has added for the use of students, as distinct from legal authorities, the following descriptive statement:—

"Cast irons are alloys of iron and carbon, with or without other elements, usually containing carbon from 1.7 to 4.5 per cent., and are not usefully wrought at any temperature. White cast irons contain free carbide; grey cast irons contain graphite; mottled cast irons contain both. Pig-irons are usually the product of the blast furnace, and are cast irons which may be either grey, white or mottled. Refined pig-irons may also be white, grey or mottled, and have had their composition, structure and properties modified either before solidification from the blast furnace or by a subsequent melting process. Malleable cast iron is the product obtained by the thermal treatment of a white cast iron, in an oxidising or neutral atmosphere, so that part or the whole of the carbide carbon is transformed into temper carbon. In the whiteheart process the carbide of the iron is partially removed by an oxidising (decarburising) ore packing, and partially converted into temper carbon nodules. In the blackheart process the carbide of the iron is wholly or partly converted into temper carbon nodules in a neutral packing without decarburisation."

Plating Zinc Die-Castings

Some useful hints on the plating of zinc die-castings are disclosed in a "Metals and Alloys" abstract of a Paper by F. E. OPLINGER read before the American Electroplaters' Society. According to the author, the plated coatings on zinc alloy die-castings are subject to blistering, especially when heated to about 300 to 350 deg. F. for baking lacquer coatings. Certain procedures and precautions will aid in preventing blistering.

The casting should be plated very soon after polishing to prevent formation of tarnish on the surface. Solvent degreasing is used to remove buffing compounds and is then followed by a mild alkaline cleaner. The solvent should not attack or discolour the surface of the casting. Cathodic cleaning requires 0.5 to 2.0 min. in a cleaner containing about 2 oz. of tri-sodium phosphate + sodium carbonate per gall. or 10 to 20 sec. in a cleaner containing 6 oz. per gall.

Anodic cleaning or simple immersion may also be used. For acid dip a solution containing 0.5 to 1.0 per cent. hydrochloric acid is used. Stronger acid solutions must be avoided. Acetic acid, 10 to 20 per cent., can also be used, but is not yet employed commercially. A strike in a copper cyanide bath is recommended before plating in either the Rochelle or high-speed copper bath.

When a casting has been properly cleaned and plated, no diffusion of copper into zinc (and therefore no blistering) takes place at 250 deg. F. in 60 hrs. At 325 deg. F. slight diffusion occurs in 2 hrs. and complete diffusion of a coating 0.0005 in. thick in 100 to 150 hrs. Diffusion takes place more readily when the casting has been cleaned and pickled too long.

Creep Strength of Cast and Forged Steels

In the concluding section of a Paper on "The Properties of Steels as a Basis for Design for High-Temperature Service," which MR. H. J. TAPSELL and MR. A. E. JOHNSON presented to the Institution of Mechanical Engineers, the authors give the following table as indicative of the relative creep strengths of cast and forged steels:—

Comparison of Cast and Forged Steels.

Steel.	Limiting creep stresses, based on a creep rate of 10^{-5} in. per in. per day at 40 days.
0.39 per cent. carbon forged steel, annealed and reheated to 550 deg. C.	13 tons per sq. in. at 400 deg. C. 10 tons per sq. in. at 447 deg. C. 5 tons per sq. in. at 507 deg. C.
0.30 per cent. carbon cast steel, annealed and reheated to 550 deg. C.	10 tons per sq. in. at 400 deg. C. 8 tons per sq. in. at 450 deg. C. 4 tons per sq. in. at 497 deg. C.
0.53 per cent. carbon cast steel (B.S. Specification No. 30, grade A).	10 tons per sq. in. at 415 deg. C.

Contracts Open

Shrewsbury, March 3—Iron castings for the year ending March 31, 1942, for the Borough Council. The Town Clerk, Guildhall, Shrewsbury.

Blackburn, February 28—Iron castings during 12 months, for the Rural District Council. The Engineer and Surveyor, 42, Wellington Street (St. John's), Blackburn.

Caernarvon, February 22—Iron castings during the year ending March 31, 1942, for the County Council. The County Surveyor, County Offices, Caernarvon.

Random Shots

Amongst the many surprising features of this war is the shortage of good drawing-room stories . . . a deplorable fact which must have preyed heavily on "Marksman's" mind, as on more than one occasion he has wakened up in the morning just as some kind soul was on the point of relating a good story! This reason alone is sufficient to kindle gratitude towards a correspondent who, having a "good one," feels he would like to share it with other readers.

* * *

The story is one of a moulder who had come back to work in the foundry, as part of the war effort, after a lapse of some years. His first day's work was hopeless. The foreman, during his round, saw a very sad effort on the scrap heap . . . scabbed, blown, and out of shape. Calling the moulder over to the heap he asked, "Did you ever see such a blank, blank casting in your life?"

"Aye," answered the moulder, "there's three more like it in the fettling shop."

* * *

Whilst everyone is pleased to learn that there is to be a more general issue of helmets in the near future, many people are wondering why they are to be made in mild steel. They feel that a medium steel would afford better protection, whilst to give a real sense of security, surely like the cigarettes a "full strength" could be used?

* * *

What's in a Name?

Raeder is certainly a good name from the German point of view for the First Admiral of their fleet, though this is counterbalanced by the Inspector-General of the Luftwaffe, whose name is General Milch.

* * *

Last week "Marksman" received a sheet of instructions to fire watchers from the local council, which consists of 24 "don'ts." But surely the fellow who stops to eliminate mentally those two dozen "don'ts" before starting on the "do's" will be guilty of the new crime of "passive sabotage."

* * *

Incidentally the most fashionable excuse for not being able to visit the wife's relations is, "Sorry, old girl, I'm on fire that night."

* * *

Making Hay while the Sun Shines

The other day "Marksman" had to wait his turn in a stamp shop while three separate customers were served with Italian Colonies. "I've got a good range here for 1s. 6d.." the assistant was saying.

* * *

"The Greeks cut up Blackshirts," runs a newspaper headline. Only, presumably, to make them up into running (away) shorts?

* * *

The nation's Home Front effort can be summed up in this slogan:—

Farmers, till your land.
Townsmen, till your money.

* * *

Definition of a Vamp.

Just one of those modern young ladies who sparkle with cosmetic rays.

* * *

After a recent raid bomb craters were found in the cricket pitch at Bramall Lane. One can imagine the groundsman, on the occasion of the next visit of Lancashire, saying to the captain: "Shall I pitch t' wickets in t' owd bomb oile or shall we rely on t' reek from t' owd brewery chimley?"

"MARKSMAN."

Some Points in Casting Production

MR. E. LONGDEN'S ADDRESS TO BIRMINGHAM FOUNDRYMEN

Mr. N. C. Blythe (Branch-President) found a fairly good attendance awaiting him at last month's meeting of the Birmingham, Coventry and West Midlands Branch of the Institute of British Foundrymen, which was held in Birmingham in the afternoon of Saturday, January 25. MR. E. LONGDEN, A.M.I.Mech.E., of Craven Bros. (Manchester), Limited, was the lecturer, and he gave an illustrated address on "Observations on Liquid Shrinkage and Contraction in Large Cast-Iron Castings."

Introducing Mr. Longden, MR. BLYTHE described him as one of a small band of men in this country whose ability and experience enabled them successfully to tackle the manufacture of castings which would frighten some founders out of the trade. He had undoubtedly gained an international reputation in his particular class of work, coupled with which he had also created for himself an expert knowledge on shrinkage and contraction.

After thanking the President for his complimentary remarks, MR. E. LONGDEN pointed out that the making of small and intricate castings also had its difficulties, and probably some preferred to make large castings rather than to do the medium-sized intricate class of work. Special problems were attached to the larger castings as well as medium castings.

Thinking that a Paper on "Shrinkage and Contraction" by itself would be rather dull, he would endeavour to make it more interesting with some remarks on moulding and the manufacture of castings generally. He had, therefore, combined two Papers, "Some Observations on Contraction in Grey Cast Iron" (prepared for the Cheltenham Conference last year) and "Some Points in Casting Production," both of which had already been published in THE FOUNDRY TRADE JOURNAL.* He commenced with an extract from the latter regarding the influence of carbon in the production of iron castings, concluding this section of his lecture by stating that the volume change due to the dissociation of carbide would account for the lower specific gravity of cast iron compared with steel and the reduction in liquid shrinkage.

Boring-Bar Production

With the aid of a series of lantern slides, Mr. Longden then detailed the methods adopted by his firm in casting three iron boring bars requiring castings of the following dimensions:—15 in. dia. by 43 ft. length, weighing approximately 10 tons; 18 in. dia. by 45 ft., weighing 15 tons; and 22 in. dia. by 47 ft., weighing about 19 tons. The 15-in. and 18-in. dia. bars were cast solid, and the 22-in. bar was lightened by cores. The bars were poured in the horizontal position, and with the many difficulties in mind the author decided, in view of the previous experiments on the influence of mould materials on cast iron, to instruct the foundry to make the castings in a metallised mould which produced remarkably sound castings.

Mr. Longden showed graphs of the cooling curves setting out the volume changes of these large boring-bar castings, and also of tests on long bed castings. After dealing with camber allowances, he concluded by saying that all those tests offered substantial support to the previous experiments carried out by him and presented to the Institute over a number of years. Mr. Longden's conclusions are:—

Contraction of Varying Sections

On the classes of iron castings surveyed, thick bars or sections contract more than thinner bars or sections, where such varied-sectioned members are linked together, as a single-piece casting, in a proximity to be affected by mutual influences. If, however, the same contrasting sections are cast as simple uniform and separate items, contraction is in line with standard allowance and knowledge—that a thin section of grey iron contracts more than a thicker section for the same analysis, because of the more rapid freezing of the lighter section and the effect of this more rapid cooling on the grain size and graphite formation.

A probable explanation of the two contrary degrees of contraction referred to is that, in the case of a one-piece casting, the thin or comparatively light sections are subjected to an extensional stress, during freezing and cooling of the metal, created by the resistance of the thicker sections which are not ready to contract. The frictional resistance of the mould and cores, and the expansion of cores on being heated up by the molten metal, will also tend to subject the cooling metal to extensional stress. Again, a study of the very clear arrest and expansion periods noted on the cooling curves, especially those of the heavy and large boring bars, indicates that a thick section of a casting may be undergoing an expansion at a time when a thinner section has passed its expansion phase and is in a state of contracting. Under these conditions the thin sections will suffer extensional stress.

Conversely, the thicker sections will be subjected to a compressional stress by the effort of the earlier cooled members to contract. Finally, the heavy sections, on cooling, must take up a shorter length by bending certain sections of the casting, or by fracture in the weakened or most highly stressed sections.

DISCUSSION

Opening the discussion, MR. W. G. BROWN (past Branch-President) described the Paper as one of exceptional interest, and assured Mr. Longden that all the troubles he had outlined applied to small castings. He instanced a particular case where the addition of a small amount of chrome had resulted in his firm having to alter a whole series of small patterns because the contraction was so pronounced that it defeated their object altogether in regard to dimensions. He was particularly interested in the method of moulding and the way the moulds were built up, and he would like to know at what stage the runner and riser heads were knocked off, and also if any difference had been made in the thickness of the denseners regarding the bottom and top of the mould, because he imagined that those at the bottom would require to be much thicker than those at the top. He would also like to know how the carbon figures shown on the slides were kept so low. Camber was a particularly involved study, but he was pleased to notice that Mr. Longden had made great steps forward in reducing the problem to a mathematical basis. The days of trial and error were passing, and foundrymen in this country were beginning to show the engineering world that those risks could be reduced to formulæ and graphs.

MR. LONGDEN pointed out that the pouring operation was done at a level above the pouring-off points, so that the pouring bushes had nothing left in them finally. So far as the risers were concerned, all they did, after pouring, was to ease round the risers, which were left on until the casting was quite cold. No effort was made to vary the thickness of the denseners. The actual carbon contents of the irons used were 3.15 and 3.18 per cent., which was not particularly low. The method of ascertaining the contraction and thermal history of those castings was a very methodical and lengthy procedure. It meant thousands of checkings, and was rather costly. In the normal way they would not expose the castings for a week or ten days.

Case of White Iron Castings

MR. G. R. SHOTTON remarked that he was very interested in the comparison in shrinkage of thick and thin sections. Exactly the same thing happened in white iron castings, but when thick and thin sections were tied lengthwise he had definitely had a casting where the opposite had occurred. The thin bars shrank more than the thicker bars. So far as camber allowances were concerned, he would like to know how Mr. Longden provided for it, as even with the vast accumulation of figures he had obtained he should have thought it was extremely difficult to take a new pattern and to estimate the camber required.

MR. LONGDEN replied that the difference between grey iron and steel in connection with liquid shrinkage lay in the fact that the graphite counteracted the liquid shrinkage. In addition to making a strong mould they also desired to form a quickly-cooled outer skin on the casting. The two together formed a barrier against varying expansion of grey iron by graphite precipitating, so that the growth of graphite was then to a great extent directed internally and largely tended to contract. The cores were not allowed to move endways because the tubes penetrated into the prints. Between each section of the core there was 2 in. of metal.

With regard to the different performances of white iron and grey iron, he would expect that for the reasons that had already been stated. So far as camber was concerned, as much as they knew about it, they did not always follow the laws. From their very extensive experience they could only judge how much should be allowed for a particular type of casting, and it was astonishing how they could arrive at the right amount. They had had large lengths of bedplate castings to make over a period of ten years, so that they had accumulated a considerable amount of knowledge. It was all a matter of experience, and in the main they managed to achieve success.

Overcoming Camber

Replying to other questions, Mr. Longden pointed out that in ascertaining the contraction and cooling performances of the bars they cancelled out of the curve the expansion of the rods. On the question of camber, the moulder had to make the bottom of the mould of the correct curvature, which was a difficult job. To overcome that he had designed two special camber strips so that they could put a definite amount of camber over the whole length. There were so many variables in the production of a large casting that it was unlikely it would come out absolutely straight. The longer the casting the more machining allowances must be made for those variables. Another important variable was the temperature of the metal. With a dull temperature they would probably have a greater amount of contraction. A long bed casting might take a bend after machining, but an allowance was made for that and the casting was seasoned for a week or two before machining. However, the machine man had a knack of making allowance for a casting bending.

In regard to the boring bars, allowance was made for extra machining on the top face because of the extra sullage; they allowed ½ in. on the bottom and ¼ in. on the top to take care of sullage, but no allowance was made for liquid shrinkage. He was not in a position to give any comparison of contraction figures in regard to green-sand and dry-sand moulds. A solid green-sand casting would shrink more than a dry-sand casting.

* The first of these Papers was printed in the JOURNAL for June 13, 1940, and the second appeared in our issues of December 12 and 19, 1940.

Preservation of Moulding Boxes

BY F. HARGREAVES.

Moulding boxes made of steel are being used more and more because they are much lighter than those of cast iron, and also because the latter will not stand the comparatively rough handling involved in knocking-out on continuous casting plants. Unfortunately, the corrosion resistance of steel is much inferior to that of cast iron, and this very definitely limits the life. Under some conditions the life of a box may be no more than four to five years. This is not the whole story, however, for the strength is being reduced continuously owing to loss of thickness, and the boxes become more easily distorted. This leads to trouble at the moulding machines, causes run-outs and imperfect joints. In fact, the total loss due to these troubles may soon exceed the cost of replacing the box.

With a view to lengthening the life of steel moulding boxes, experiments were commenced in 1936 on boxes protected by three different surface treatments. The bottoms only were dealt with, and these had dimensions 14½ in. by 17½ in. by 5 in. deep. Each had two horizontal stays. The treatments given were as follow, two boxes being treated by each method:—

Mark G.—Galvanised in the ordinary way.
Mark Z.—Metal sprayed with zinc on the inside to a thickness of 0.004 *in.*
Mark A.—Metal sprayed with zinc and then with 0.004 *in. of aluminium.*

In our issue of December 5, 1940, we suggested editorially that experiments carried out on the surface treatment of steel moulding boxes might yield valuable results. The author of this important article shows how galvanising has been particularly effective.

In addition, six boxes were put into service at the same time with no treatment, and were marked P.

The boxes were of welded construction, and it was feared that the galvanising treatment might cause warping, and thus necessitate subsequent trueing of one edge by grinding. This did not prove to be necessary. The galvanising treatment was the cheapest, and amounted to less than one quarter the cost of the steel box.

The twelve boxes were put into service on the continuous casting plant and have been used 10 to 12 times each per day for 5½ days a week. They have been brushed off and examined at intervals for signs of rusting. The results are given below, and the remarks apply to the *inside* of the boxes:—

Date.
22.10.36.—Put into service.
16 . 7.37.—All as new.
6 . 9.37.—G—As new. Z—Each started to rust in a single area. A—The aluminium coating shows flaking on one stay.
20.11.37.—Remarks as 6.9.37.
6 . 5.38.—G—As new. Z—Both stays of each box rusting, and one rusted on one side. A—Each shows flaking of the aluminium on one stay.
8 . 9.38.—G—As new. Z—Stays rusting; one box shows intensive rusting on one side and the other shows rusting on one end. A—No rusting.
8 . 9.39.—Remarks as 8.9.38.
25 . 1.40.—G—As new. Z—Both show extensive rusting. A—Some corrosion on stays only.
16.12.40.—G—As new. Z—Both show general rusting. A—Corrosion on stays only.

The weight of the castings in each box is about 40 lbs., exclusive of runners.

The early results were sufficiently promising for complete moulding boxes to be put into service in the galvanised condition on August 31, 1937, and since then all new boxes have had this treatment.

The bottom section had horizontal stays and the top section two vertical stays. The tops which were put into service on August 31, 1937, when examined on December 31, 1940, showed rather bad corrosion on the outside edge of the stays, but the insides of the boxes were as new. It is probable that mechanical damage of the galvanising in service is responsible for the corrosion of the stays.

To sum up, therefore, it appears that, apart from mechanical damage, galvanising gives perfect protection from corrosion for a period exceeding four years. Further, there appears no reason why, with appropriate repair and re-galvanising when necessary, moulding boxes should not last indefinitely. As the cost of galvanising is less than one-quarter that of a new steel box, the saving in cost of moulding boxes is considerable.

The actual life of these particular boxes, when not galvanised, cannot be given exactly, but one supply lasted only four years. In the present test six untreated boxes were put into service, marked P, along with the treated ones, and, although extensively corroded, they are not yet giving trouble after fours years of service.

Emergency Pipe Repairs

REVIEW OF ALTERNATIVE METHODS

Notes issued by the Building Research section of the Department of Scientific and Industrial Research, entitled "Emergency Pipe Repairs" (Wartime Building Bulletin No. 12),* bring together what is known both of thoroughly well-tried methods alternative to lead jointing and of others of a less established nature which are worth trying under appropriate conditions. Not all of the methods of pipe jointing are suitable for all classes of work; for example, the jointing of high-pressure water mains where the head is commonly as high as 200 ft. and in some cases as high as 800 ft. obviously presents special problems owing to the risk of jointing materials being extruded from the joint. But willingness to depart from normal peacetime methods and a readiness to consider any alternative which is reasonably well adjusted to the circumstances are essential for effective wartime service.

The Bulletin deals with: (1) Fully mechanical methods: all of these involve the use of rubber rings which are compressed to form an impervious seal by a variety of means, either (*a*) compressing a rubber ring in the space between spigot and socket by means of screw threads or a flanged collar tightened down into the joint, or (*b*) compressing either one or two rubber rings beneath a collar slipped over the junction of two plain ends of pipes. These types of joint are very quickly made—sometimes in minutes only as against hours for caulked joints—and only a day or two is required for operatives to become thoroughly familiar with the fitting of even the most complex types. (2) Plastic or liquid caulkings: The range of materials used for jointing pipes is greater than sometimes supposed. They include under the heading "plastic fillings" the following:

(i) *Rust-cement*: A mixture called "rust-cement" well known for jointing cast-iron low-pressure hot-water pipes. Two formulæ which have been given are: 80 parts iron borings, 2 parts flowers of sulphur, 1 part powdered sal ammoniac; and 90 parts iron filings, 1 part sulphur, 1 part sal ammoniac. The mixture is moistened with water one or two hours before use. Then the joint is caulked with oakum or yarn to ⅓ of its depth, and this is followed by the rust-cement. It is said to form a tight permanent joint.

(ii) *Portland cement*: Portland cement is regarded in this country as the standard jointing material for stoneware and for concrete, not for cast iron and steel, but there is no intrinsic reason why it should not be as good for the latter as for stoneware. The chemical similarity of joint and main in concrete pipes is an evident reason for its success in this application. Yet cement has been used quite widely in America, but not much in this country, for jointing cast-iron mains.

(iii) *Bitumen-cement mixtures*: The combination of bitumen emulsion with Portland cement yields an interesting mixture intermediate between the properties of asphalt and cement mortar. It makes a highly workable mortar when freshly mixed and should be very resistant to percolation.

(iv) *Rubber-latex with cement*: A valuable range of mixtures is obtained by the incorporation of rubber-latex with cement. In combination with cork, marble or sand, they have been successfully used for flooring, and other mixtures have been used on ships' decking and for levelling out the laps at the junctions of steel hull plates to reduce the frictional resistance of the hull. The outstanding characteristics of this group of mixtures is their exceptionally strong adhesion to a variety of surfaces, such as metals, brick and concrete. The possession of a distinct elasticity is an additional feature which suggests their probable usefulness for jointing pipes. Two firms with whom the subject has been discussed have made suggestions for mixes. One is of the following composition: 2 parts (by weight) rubber-latex paste, suitably stabilised; 6 parts powder containing cement constituent; 1 part cork. The cork is recommended as tending to maintain a good degree of elasticity. The mixture has good plastic qualities and a trial of filling a cavity having similar dimensions to a spigot-and-socket joint suggests that no difficulty will be experienced in filling solidly. The density is only one-ninth that of lead, so the weight of material to be handled would be smaller.

Poured Fillings

(i) *Bitumen.*—Bitumen is one of the few pourable pipe-jointing compositions, and is suitable for stoneware pipes for drains and sewers. In these the pressure is very low, usually not more than atmospheric and, under pressure, extrusion of the jointing material is to be feared. Its use might be extended to other types of pipe which might be required for carrying away drainage water.

(ii) *Sulphur.*—Mixtures of sulphur and sand have been used for jointing vitrified clay pipe. The following composition has been quoted: 1 part powdered sulphur; 1 part sand, 90 per cent. passing 100 mesh sieve, and 50 per cent. passing 200 mesh sieve. The mixture is heated till it is just molten (260 deg. F.) and then poured. It is inexpensive and said to be absolutely watertight and rigid, though it has a tendency to cause cracking.

There are evidently possibilities in the use of pourable compositions for emergency mains, but it is thought that their field of applicability is very limited and that if supplies of fully mechanical joints prove inadequate to meet all requirements, the plastic compositions described in the foregoing section are more promising.

* H.M. Stationery Office, York House, Kingsway, London, W.C.2. (Price 6d. net.)

Special and Alloy Steels

PRESIDENTIAL ADDRESS TO SHEFFIELD SOCIETY OF ENGINEERS AND METALLURGISTS

Dr. W. H. Hatfield, F.R.S., President of the Sheffield Society of Engineers and Metallurgists, delivered his presidential address at the meeting on January 25, taking as his subject "Special and Alloy Steels."

DR. HATFIELD said, at the outset, that we were living through a very critical time, and the subject which he had chosen for his address was a very important one, for it was true to say that the success of our cause—which was unquestioned—would be due essentially and fundamentally to the quality of the steels that we were able to provide for the Services.

He then exhibited a slide containing information concerning the various elements which steelmakers used to convert that very simple ductile material, iron, into those widely dissimilar metals which were employed for armament and other Allied purposes. One column of the slide showed where the ore of the metal was found, and another where the ferro-alloy, or the reduced form, was produced. He was delighted to be able to state that, owing to the successful action of the armed forces of the British Empire, they were not short of any of those elements. One must couple with that the effective action of the Steel Control in arranging that, in view of the protection by the armed forces, it was possible to bring those metals in suitable quantities and suitable form to our shores.

He felt that this was a magnificent position. It went beyond the simple metallurgical fact that all the elements they needed were available to them, and, so far, in the quantities in which they required them. It was the function of himself and his colleagues in the industry to take an interest in the relative influence of the various alloys in inducing the properties in which they were interested, and they had to have in mind the possibility, but he did not think the probability, of a variation in the incidence of availability of the different elements, so that they could, should circumstances arise, transpose one element for another, as it were. However, it was interesting to realise that the whole of the special elements came from abroad, and that, owing to the armed forces of the Crown, these necessary resources, from all over the world, were still available to them.

Economic Aspect of Steelmaking Alloys

Next, the speaker continued, he would like to draw attention to the economic aspect of the various elements. In one column of the slide he stated, in pence per lb., the price of each of the elements which they added to steel. He had, in a most arbitrary way, postulated a loss in melting which differed with the different elements, and then he had deduced the cost of adding 1 per cent. of each element to steel. The importance of this at the present juncture was quite considerable. All that one really needed, in wartime, was to produce the properties required for a given application, under the most economic and convenient circumstances. Thus one might say, for instance, as his colleagues within the industry and himself had said, that high-tensile properties could be induced by adding manganese and molybdenum; those elements might well replace the application, which had continued, of very rich or rather much richer nickel-chromium. All these questions must be to the fore while the war lasted.

The table on the slide showed that every 1 per cent. of nickel which they added to steel increased its cost by £1 19s. per ton, or say roundly £2. Suppose they were using manganese-molybdenum instead; 1 per cent. of manganese from high-carbon ferro-manganese would increase the cost of the steel by 6s. 4d. per ton, while 1 per cent. of molybdenum would mean an increase of £6 14s. 5d. per ton. One might deduce from this that something like 0.3 per cent. of molybdenum would cost about the same as 1 per cent. of nickel. If they were adding 1½ per cent. of manganese, which cost about 10s., and 0.3 per cent. of molybdenum, costing £2, this gave a total of £2 10s., whereas the use of say 3 per cent. nickel would cost about £6.

There were other cases of the same kind. It was purely an arithmetical problem, always subject to the results achieved being what they wanted. They could play the tune on the various elements, not only from the intrinsic physico-chemical point of view but also from the cost point of view, and he would strongly commend to all of them a consideration of the matter from that angle.

Other Cost Factors

He warned his audience, however, against deducing the difference in price between ordinary steel and alloy steel by virtue of a simple calculation based on the value of the added elements. That had been done, and with great disaster to those who had relied upon the result. They all knew what a costly material rustless steel was, for instance. When they added these special elements to steel they not only increased the cost by increasing the intrinsic value of the materials employed, but also produced disabilities as regards fabrication. A steel to which alloys had been added must be worked very differently from the carbon steels. When the alloys were present over a certain proportion they required special annealing, slow cooling and so on, so that the ultimate value of an alloy steel was not to be ascertained in a simple way by merely adding up the value of its constituent parts in terms of the elements.

As a result of the efforts of metallurgists over the last 70 years many ways had been developed of adding the various elements to iron, sometimes by themselves and sometimes in combination with others. They could increase the strength of plain carbon steels by simply increasing the carbon; with a little more manganese than normal they got a stronger steel; by adding silicon to manganese steel they got spring steel; with manganese and molybdenum they got high-tensile steel; and there were many other combinations, using nickel, chromium, aluminium, cobalt, copper, titanium, etc. The different elements were sometimes present in small proportions, but at times they constituted a very considerable part of the weight of the alloy. Sometimes alternative compositions produced the same characteristics, *i.e.*, by different combinations even of different elements they might arrive at the same result, but very often indeed the result produced by a combination of elements was unique. Of course, in such cases such steels must be used only for the purposes for which they were really needed in wartime.

The various systems resulted in the production of carbon steels, alloy steels, case-hardening steels, nitriding steels, spring steels, steels of special physical properties, engine-valve steels, rust- and acid-resisting steels, heat-resisting steels, tool steels, magnet steels, armament steels, etc. No firm in Sheffield made all those grades, but it was true to say that the special steel metallurgy which had been evolved, producing this useful series of steels, was really the basis of modern Sheffield steel metallurgy.

Progress in the Last Two Decades

The next section of Dr. Hatfield's address dealt with steel metallurgical progress since the last war, and presented a very striking story, much of which, he said, he did not discover until he was asked to prepare the address. What he had to say on this subject, he remarked, held out very great promise indeed for the future.

It was amazing to reflect that since the last war, which finished in 1918, free-cutting steel had come into existence. Since the last war they had introduced high sulphur and the lead addition, producing the free-cutting steels, and they really were easier to cut than the steels which were not free-cutting. The manganese-molybdenum steel, which was so promising as a high-tensile steel, had been evolved since the last war; and so had the manganese-nickel-molybdenum, another very good high-tensile steel. The chromium-molybdenum steels were evolved since 1918, particularly the 3 per cent. chromium, 0.45 per cent. molybdenum, and the 6 per cent. chromium, 0.45 per cent. molybdenum.

Not only had this remarkable series of steels come into existence since the last war, but the great nitriding technology was also subsequent to 1918. They had the chromium-aluminium nitriding steel, and the chromium-molybdenum nitriding steel—that was a phase of metallurgy which was quite new since the last war.

Then they had valve steels. It was an amazing thing to him to realise that even the present chromium-silicon valve steel was not in use in the last war. The chromium-nickel-tungsten steel was evolved a considerable time after that war.

Coming to rust- and acid-resisting steels, stainless iron was developed after 1918, and so was the high-tensile 18/2 rustless steel. Apart from the original discovery of Brearley, of the 12 per cent. chromium and approximately 0.3 per cent. carbon steel used for cutlery, the whole of the rustless-steel metallurgy had been developed since the last war. Heat-resisting steels were practically non-existent in the last war, but since then they had the 25 per cent. chromium—20 per cent. nickel, 30 per cent. chromium, and, of course, the very rich nickel-chromium alloys.

New Magnet Alloys

In the case of magnets, for some time in the last war a coercive force of 70 to 80 was regarded as almost the theoretical limit of what they were likely to obtain from a magnet, and yet since then they had evolved the high-cobalt steel, the nickel-aluminium-cobalt, and the nickel-aluminium, and they had a coercivity of 400, 500, 600, as against 60 to 80. They had magnets of an efficiency and power which were entirely contrary to all the theoretical standards of the period, looking at the matter from the standpoint of the last war. He would go further and say that had they, on purely theoretical grounds, endeavoured to deduce what elements added to iron would produce a high coercive force they would never have thought of adding nickel and aluminium; on the contrary, their knowledge to that date, based on experiment, led them to believe that they simply depreciated the value of a magnet by adding either nickel or aluminium. When they came to tools, he did not think there had been very much development as regarded tool steels, but there had been the introduction of the hard metal carbide alloys.

He had not mentioned all the developments, but in what he had said they had a statement of scientific and technological development in alloy steels since the last war which had entirely

(*Continued on page* 114.)

Non-Ferrous Metals in 1940

SMOOTH WORKING OF THE CONTROL

With the exception of tin, prices of base metals were controlled throughout 1940, market dealings in copper, lead and spelter on the London Metal Exchange being suspended. From time to time, criticisms of the system under which the sale of metals was vested in the Controller of Non-ferrous Metals were heard, and it is, of course, obvious that those houses which formerly carried on business both on and off the Metal Exchange suffer under such a scheme. Nevertheless, the plan has worked extremely well on the whole and the obligation laid upon consumers to acquire licences from the Control before they can secure supplies of raw material ensures that metal is diverted into the right channels of consumption.

Majority opinion holds the view that central control by the Government is the best possible method of handling a difficult situation and stresses the fact that prices of non-ferrous metals in this country throughout last year were well below the world price as represented by the quotations obtaining in New York. Renewal of the Government's purchasing arrangements with Empire suppliers ensures that the British war effort will continue to derive all the advantages accruing from an ample provision of metals at relatively low prices and, with the experience of 1940 to rely upon, the trade can look forward to 1941 with confidence.

Satisfactory Copper Supplies

The Control of Non-ferrous Metals (No. 5) Order, 1939, came into force on December 18 of that year and, owing to the proximity of the Christmas holidays, it was the New Year before much buying at the revised level took place. On the whole, consumers have appeared to prefer the quotation on a delivered basis, as during a year when from time to time transport has not always been easy to arrange, the onus of bringing metal to the works has been upon the Ministry of Supply. This arrangement has not, however, applied to the revised prices for scrap, which under the new arrangement are quoted "ex seller's premises" and are therefore subject to an additional charge for carriage.

Throughout the year under review values of virgin copper and secondary brass and copper remained stable in this country and there does not appear to be any reason why any change should take place in the near future. Demand was on an ever-increasing scale, especially from May onwards, and there can be no doubt that the total consumption in this country last year broke all records, although actual figures are, of course, not available for publication. Practically all the business done was through the medium of the Control, but a modest tonnage, some of it made available through the Prize Courts, passed through the hands of merchants, the purchaser being obliged to furnish a licence issued by the Controller of Non-ferrous Metals. It seems doubtful whether any tonnage worth mentioning was purchased outside the sterling *bloc* and the Empire has continued to cover the needs of this country in all grades of copper.

Following the collapse of France and the cessation of fighting on the Continent, Katanga copper from the Belgian Congo became available for this country and this was a useful addition to Empire supplies. After France ceased fighting it was suggested that the balance of her outstanding purchases from the United States should be taken over by the British Ministry of Supply, but there is no evidence that this actually took place. Quite a fair amount of "distress" copper is, however, supposed to have reached our shores last year as the result of seizures on the high seas, for naturally there was copper moving to France from America when the collapse came and this was not permitted to reach its intended destination. The second half of last year, therefore, saw an improvement in the statistical position here and it is probable that the authorities were able to put metal into reserve against a rainy day.

The London Metal Exchange stocks of blister copper lying in official warehouses were dealt with during the autumn of 1939, but last year saw further quantities taken over by the Ministry of Supply from various warehouses in the country and it is safe to assume that all usable metal has now been secured for the munitions programme. Steps were also taken to encourage the conversion of scrap and residues into blister copper, the Ministry of Supply offering to buy to a specification everything produced by the smelters.

Prices in New York

If the price of copper in this country was stable last year, the same cannot be said of the market in New York, where from time to time a fair amount of fluctuation took place. The year opened with the domestic and export quotations at 12.50 cents, but demand was not very brisk, and by the end of the month values had declined to 11.62½ cents, for Customs smelters were shading prices in order to attract business, and the primary producers, too, after holding on to 12½ cents since the beginning of the war, finally gave up the struggle and came down to 12 cents. General business in the United States was not at all brisk, and there was talk of curtailment of production in copper if matters did not mend. In February, smelters were down to 11.12½ cents, and producers had reduced to 11.25 cents. Export bottomed at 11¼ cents f.a.s., but there was a good deal of fluctuation from day to day. After touching 11 cents a rally in the domestic price came in May, when Holland and Belgium were invaded, but after staying at 11½ cents through most of June the collapse of France brought a spasm of weakness, and in July domestic copper touched 10.45 cents and export 10 cents, for it was realised that the European market, which had absorbed so much Chilean copper, was virtually closed.

The placing of British Government orders in the United States, and the announcement of an ambitious rearmament programme, imparted a firmer tone in August, 11 cents being achieved at the end of the month, but export was weak at 9.75 cents f.a.s. In September, domestic copper reached 12 cents, but it was not till October that the export figure picked up as a result of an arrangement under which Chilean brands lying in bonded warehouses in the U.S. were used for the execution of fabricated material intended for export. It began to be realised, too, that supplies were not very adequate, for following sales approximating 375,000 short tons during September and October, prompt metal was far from plentiful. For a brief period Customs smelters raised their selling limit to 13 cents, but the authorities frowned on this and the market dropped back to 12 cents delivered Valley, with export around 10¼ cents, f.a.s.

No survey of the past year would be complete without a word about scrap metals, for which a schedule of maximum prices is provided. In a few words, the events of last year consisted in declining interest in secondary material as the virgin metals position improved, and an accumulation of the lower-grade scraps and residues on account of the disappearance of Continental markets. Holders of first-class copper scrap and cartridge metal found that they could sell their material twice over, but any parcel requiring additional handling or likely to slow down production in the foundry was looked at askance. While prices of the best grades kept up to about the maximum permitted under the Order, some of the commoner qualities, as, for example, braziery copper and brass swarf, were available during the second half of the year at well below the upper limits permitted by Control Order No. 5. That there has been some accumulation of residues cannot be doubted, but this is a matter which can hardly be avoided in the present circumstances.

American Tin Buying

There was a good deal of variation in the price of tin last year, the lowest quotation occurring on January 22, when £232 was touched, and the highest on June 14, when the three months' price touched £292 and cash £290 10s. June was, as a matter of fact, the most active month of the year on the London Metal Exchange, the turnover being about 6,780 tons, which compared with about 5,500 tons in January. From July onwards the trend of activity was downwards, and during the autumn turnovers were running at about 500 tons per week. The year opened with production at 120 per cent., but in view of the paucity of demand and declining prices in the early part of the year, a downward adjustment to 80 per cent. was announced. This drastic revision led to an improvement in the position both statistically and in values, but it was found that the cut had been overdone, and in May the quota for the third quarter was fixed at 100 per cent. of standard. By this time it was obvious that demand for tin had materially increased, and, moreover, the smelter at Arnhem, in Holland, had fallen into enemy hands when the Low Countries were overrun. Then, in July, came the news of the American Government's intention to purchase as a special war reserve 75,000 tons of tin at 50 cents, delivery to be spread over twelve months. In order to cope with this the production rate was lifted to 130 per cent., which virtually meant that all restriction on output was removed.

During the first half of the year, a backwardation was almost constantly in evidence, the position growing increasingly difficult until on April 25 the premium for cash reached £5 5s. This made hedging operations very awkward and the market suffered accordingly, so that the change-over to a contango, when it came, was welcome. By the second half of June this was fairly well established and trading conditions were all the healthier for it.

Throughout the year transactions in tin futures continued on the London Metal Exchange, business often being conducted under difficult conditions, but although trading in the other metals was suspended, every week from Monday to Friday saw two "rings" daily in tin and a fair gathering of members to participate. Smelting operations in this country have continued at high pressure and the total of stocks revealed in the official warehouse figures has kept up well, but, in addition, it is understood that the authorities, with an upper limit of £260, set out to buy tin to act as a special reserve. As always, the tinplate industry has been the mainstay of the demand for tin, but in this country rationing of steel supplies made for a downward trend in the production curve in South Wales during the second half of last year, the demand for tin falling off accordingly.

No review of last year's activities in tin would be complete without reference to the decision to set up a smelter in the United States

(*Continued on facing page.*)

Acid-Resisting Cast Iron

THE USER'S POINT OF VIEW

In a Paper on "Modern Developments in the Design of Plant for the Concentration of Sulphuric Acid," which was read before the Institution of Chemical Engineers by MR. P. PARRISH, F.I.C., extensive reference was made to the castings embodied in such plant. By permission of the Council of the Institution we publish below those parts which we deem to be helpful to the foundry industry.

Cast-Iron Vessels

Cast-iron pots have been used for the concentration of sulphuric acid since 1897, but up to 1932 these were of relatively small size, compared with the pots which have been installed in this country since 1937, with a view to concentrating denitrated waste acids from 68 to 70 per cent. to 96.5 to 97 per cent. H_2SO_4, at a rated capacity of about 20 tons per unit per day. Continental firms had earlier experience of the operation of these cast-iron pots and pans than acid manufacturers in this country. Experience of the operation of these cast-iron vessels by Continental works was not altogether trouble-free. Some data relating to cast-iron pots and a cast-iron pan are given in Table I. The cast iron employed and the method adopted for casting the vessels are matters of importance. In Table II are given the results of analyses of cast irons which have been used in the fabrication of pots and pans for sulphuric-acid concentration.

TABLE I.—*Data on Cast-Iron Pans.*

Type.	Dimensions.	Effective heating surface. Sq. ft.	Rated capacity per 24 hrs. 96–97 per cent. H_2SO_4. Tons.	Ratio of surface to volume. Sq. ft. to cub. ft.
Cast-iron pot	7 ft. internal dia.	120	10–12	0.71
Cast-iron pot	7 ft. 9 in. internal dia.	150	12½–16	0.63
Cast-iron pan	11 ft. 6 in. by 8 ft. 3 in.	163	15–18	1.00

TABLE II.—*Analyses of Cast Iron Used for Pots and Pans for Concentration of Sulphuric Acid. (Results as Percentages of Total Weight.)*

Type.	T.C.	Gr.	C.C.	Si.	Mn.	S.	P.	Ni.
G1 ..	2.5–3.5	—	—	1.0–2.0	0.5–0.8	—	—	—
B2 ..	3.58	3.2	0.38	2.96	0.82	0.009	0.033	—
E3 ..	3.30	—	—	1.00	0.70	0.080	0.030	1.1
E4 ..	2.3–3.75	2.0–3.0	0.3–0.75	2.0–4.0	0.5–0.7	0.070	0.3–0.6	—

English Chemical Cast Iron

Table III gives the physical characteristics and an average analysis of English chemical cast iron.

Nickel and chromium have been used as constituents of cast irons for the purpose of inhibiting grain growth; but care should be exercised in the introduction of these metals. While it is not doubted that grain growth can be inhibited, the vital consideration is what is the effect of the introduction of these metals on their resistance to corrosion? The data in Table IV from tests on corrosion are significant.

As the cast iron has a weight of ¼ lb. per cub. in., the weight for each square foot of a pot of 2-in. thickness would be 72 lbs., or 226 grms. for each square inch of exposed surface. On the basis of the figures in Table IV, the loss of the nickel-containing cast iron by corrosion would be 5.96 grms. per sq. in. per week, or complete loss by corrosion in about 38 weeks. The corresponding loss by corrosion with the cast iron not containing nickel would be 2 grms. per sq. in. per week, or complete loss by corrosion in about 113 weeks. The results of laboratory tests designed to determine corrosion-resistance, however, must be used with reserve. It is important to note whether the samples are wholly coated with a skin, or whether part of the skin has been removed in the preparation of the sample.

TABLE III.—*Physical Properties of English Chemical Cast Iron.*

Specific gravity	7.2
Coefficient of linear expansion	0.000006
Specific heat	0.122
Thermal conductivity, e.g.s. units	0.199 (1–0.0029t)
Tensile strength	Approx. 10 to 15 tons per sq. in.
Graphitic carbon	2.0–3.0 per cent.
Combined carbon	0.3–0.75 „
Silicon	2.0–4.0 „
Manganese	0.5–0.7 „
Sulphur	Up to 0.07 „
Phosphorus	0.3–0.6 „

TABLE IV.—*Corrosion Tests on Cast Iron.*

	Nickel-containing cast iron.	Cast iron without nickel.
Original weight, grms. ..	18.433	16.386
Duration of test, hrs. ..	67	67
Loss in weight, grms. ..	5.383	1.820
„ „ „ per cent. ..	29.2	11.1
Surface area, sq. in.	2.2875	2.2875
Loss in grms. per sq. in. per 100 hrs.	3.513	1.343

Another factor to be considered is the protective influence which the sulphate of iron will afford to the skin of the cast-iron pot. That it has a beneficial influence cannot be doubted, but it is difficult to express it in definite terms. Further, the practice is to allow the cast-iron pots which have been delivered by the foundry to remain in the open for some time, in order to oxidise and mature before being used. Presumably a kind of "normalising" process occurs.

All cast-iron pots reveal signs of corrosive attack when put into operation initially. One should not be unduly alarmed at this, but should continue to maintain a predetermined uniform temperature of the acid, and the rate of production. After a limited period of 12 to 36 hours the cast-iron pot forms its own protective coating, and the corrosion subsides, once a non-corrodible film has been formed.

Casting of Pots and Stills

Ironfounders in the St. Helens and Widnes area of Lancashire have been accustomed for many years to cast pots for caustic alkali. They have developed a technique which is peculiarly their own, and as a result of much experience have given satisfaction to those to whom the large cast-iron caustic pots have been supplied. The spiral form of pouring which has been adopted in some cases has proved invaluable in the preparation of large-sized pots for the concentration of sulphuric acid. Another firm has indicated that its general practice in fabricating stills and pots is to cast from the top with twelve runners on a diameter of 8 ft. These runners are all fed from a common circular reservoir, into which the metal is poured from the ladle. Before the metal enters the mould, the reservoir is filled and the metal held by plugs over the holes; the plugs are then simultaneously removed. With a large still or pot, it has not always been found practicable to cast from the bottom, owing to the limited number of runners available for use. Where the casting has to be machined on the top

Non-Ferrous Metals in 1940

(*Continued from facing page.*)

with the object of dealing with Bolivian ores in the production of high-grade tin suitable for American consumers. Negotiations over the establishment of this plant followed a protracted course, for a good many people were rather half-hearted about it, but the scheme is now going ahead and a start will be made this year on the basis of a capacity of about 20,000 tons per annum.

Another matter for comment in regard to events last year is the discrepancy in values between New York and London, as a result of which there was considerable agitation for permission to export from this country to the United States. Finally, it was announced that export licences would be granted to function from November 1 onwards and on this news values improved by about £12 in one week at the end of September. Actually, the tonnage exported has not been large, as it was felt to be necessary to safeguard the position of stocks at home.

Lead and Spelter

Throughout last year trading in lead was suspended on the Metal Exchange, but the price of virgin metal was kept steady at the Control maximum of £25 delivered consumers' works. Generally speaking, the supply position remained comfortable and it is probable that the Ministry of Supply was able to build up reserves to some extent. This country's needs were met by the output of Empire mines in Australia, Canada, Burma, etc., and, in addition, consumers were able to purchase remelted pig at prices which in the autumn showed an advantage over virgin metal of as much as £4 to £5 per ton, a hint, perhaps, of the "true" trend of lead prices. At the end of July the Ministry of Supply announced that it was prepared to buy pig-lead refined in the United Kingdom at £22 10s. f.o.r., provided that the lead content was 99.98 per cent. minimum, with certain limits for impurities. It is believed that few offers in response to this have been forthcoming.

Demand in this country for spelter reached a very high level last year, but it was found possible to provide all the metal required, although in the later months it seemed as if the margin between supply and demand was not perhaps quite so comfortable as earlier in the year. Prices were unchanged throughout the period under review and there is no suggestion of any alteration. In the United States, the autumn months saw a very tight position, with stocks in producers' hands down to ten days' supply, and the price firm at 7¼ cents. Actually the year ended with stocks standing at less than 13,000 short tons, deliveries for the month of December exceeding 65,000 short tons, but steps are being taken to bring additional refining capacity into play and the present year ought to bring amelioration of an admittedly unsatisfactory state of affairs.

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flange, the practice is to cast on a head 8 or 10 in. thick over the area of the flange. This gives the necessary density to the top of the casting.

Designing Special Parts in Cast Iron and High-Silicon Iron

The statements made in 1924[1] about designing special parts to be cast in iron or high-silicon iron are equally true to-day. Durability and cost are important considerations.

"(1) Large flat surfaces should be avoided, and the thickness should be kept as uniform as possible. (2) Where inequalities in thickness are unavoidable, the change in section should be a gradual one. (3) Sharp, square corners, whether internal or external, are a source of fracture, and they should always be avoided. (4) All large flanges should be webbed, and slots provided, rather than bolt-holes. (The latter consideration has particular reference to silicon iron.) (5) Long, projecting pipes on large vessels should be avoided, and the design generally kept as simple as possible, so as to make moulding and coring comparatively easy.

"Defects arising through faulty moulding are most frequently due to the presence of gas in the moulds or cores, the result of which is the formation of blowholes or scabs.

"Blowholes occur in the interior of the casting, and cannot usually be detected from the outside. They may be caused by the use of very wet sand, or an imperfectly vented mould. Casting at too low a temperature, or with an excess of sulphur, also gives rise to the defect. The sudden failure of a pot or dish is often due to the presence of a large blowhole beneath the skin of the casting. In such a case, and if the article is otherwise sound, the faulty patch may be drilled out and plugged. Large blowholes can generally be discovered, however, by a hammer test.

"A scab is an irregular excrescence caused by the erosion of a part of the mould. Violent evolution of gas in any part of the mould will break up the sand, which will then be washed away, and the resulting cavity filled with metal. The incorrect placing of risers and gates will also produce the same effect. A small scab on a large casting is not of itself a very serious defect, but the presence of large scabs means that the displaced sand is contained in the casting, which should therefore be rejected. An apparent scab is sometimes proved to be a cavity (resulting from the careless removal of a riser or fin) filled with iron cement.

"'Honeycombing' is usually apparent on the surface of the casting. It consists of a number of small cavities in close proximity, and is generally due to dirty metal and inefficient skimming. Spongy, or honeycombed, castings should never be accepted, particularly when the article is a vessel in which concentration of acid is to be effected."

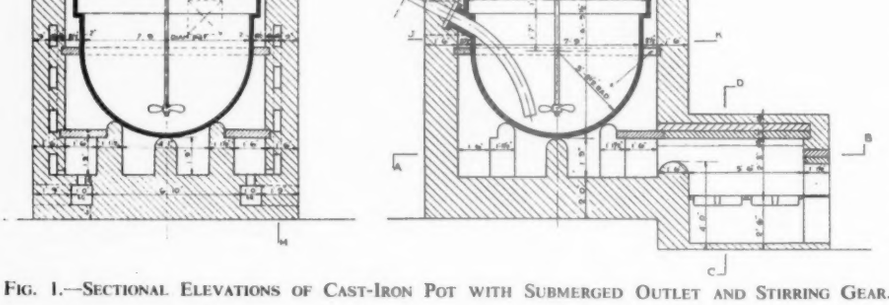


FIG. 1.—SECTIONAL ELEVATIONS OF CAST-IRON POT WITH SUBMERGED OUTLET AND STIRRING GEAR.

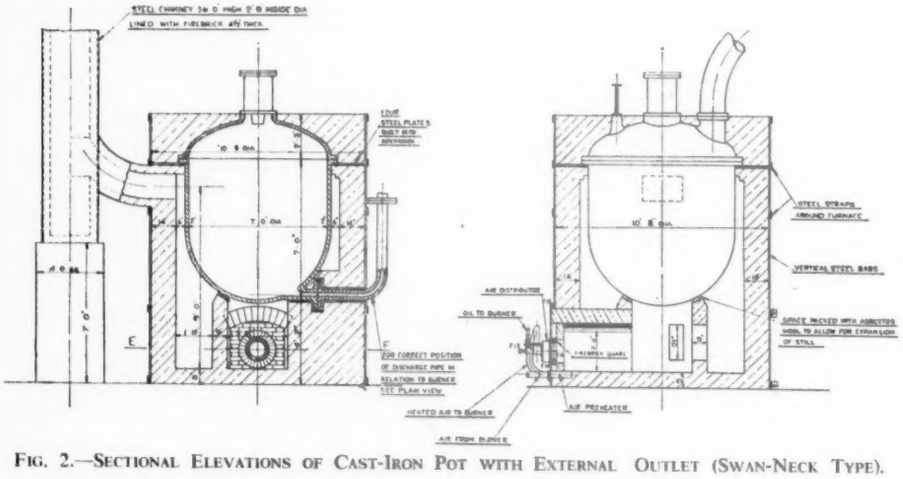


FIG. 2.—SECTIONAL ELEVATIONS OF CAST-IRON POT WITH EXTERNAL OUTLET (SWAN-NECK TYPE).

Examination of Cast-Iron Vessels before Delivery

A competent inspector should examine all castings for the user. He will be able to discern cavities by the hammer test, and will be able to detect readily any signs of faulty casting. It may be desirable to apply a hydraulic test of 100 lbs. per sq. in. on all vessels.

Shape and Relative Merits of Pot and Pan

Several questions arise when considering the form and shape that the cast-iron pot should take. In applying heat as much unimpeded surface as possible is desirable. It is essential to provide means of supporting the pot from a top flange. Whether this support needs to be supplemented is open to question.

It would appear that there is a limit to the size of cast-iron pots, and perhaps a diameter of 7 ft. 9 in. is the largest for which foundries in this country have the necessary equipment. The possibility of foundry faults must increase with the size of the casting.

The two considerations governing the thickness of the pot are corrosion and mechanical strength. The limits demanded by mechanical strength have invariably to be exceeded in order to provide an adequate thickness of metal against loss by corrosion. There is always a minimum thickness at which pots have to be discarded, and the greater the initial thickness above this minimum the greater the length of life.

The desire to reduce the volume of acid in relation to the effective surface area for heat transfer is a dominant one, and this finds expression in the use of the cast-iron pan (Fig. 1). This form avoids difficulties with the outlet, but there are few foundries in this country at the present time which could equip themselves, without much inconvenience, for the casting of these pans.

There is always a tendency for corrosion to occur on the wind-and-water line, and some chemical engineers prefer to provide a recess, which admits of lining the pot at this critical point with acid- and heat-resisting radiused tongued and grooved tiles, whereas the practice in other cases has been to thicken the castings at this point.

Outlets of Cast-Iron Vessels

There are advantages and disadvantages of external and internally-submerged outlets. An externally-arranged outlet, as shown in Fig. 2, necessitates a core, and may conceivably cause difficulties in casting. Given a good casting, it is an easy matter to construct a ring, or bull's-eye, around the boss, to pack the space with slag wool and asbestos, and to employ suitable semi-circular disc closure tiles, in such a way as to avoid any strain.

When renewing a swan-neck it is necessary to syphon out the acid, whereas with the submerged internally-arranged outlet (Fig. 1), only part of the acid needs to be removed. The submerged internally-arranged outlet is subject to corrosion by acid both intenally and externally, whereas the swan-neck type is only subject to internal corrosion. Difficulty may occur in withdrawing the internal outlet for renewal; on the other hand, the external outlet can be disconnected and removed without much trouble.

The outlet boss or flange of the pot should be accurately machined, and preferably recessed: the swan-neck should be provided with a short spigot end, and accurately machined. In the case of the submerged outlet, the flange of the dip pipe must be machined on both faces, as also the pot and connecting pipe. A thin joint of asbestos millboard, say $\frac{1}{16}$ in., should be employed.

HIGH-SILICON IRON

Observations made under the "Utilisation of the Sensible Heat of the Chimney Gases" and "Dephlegmator" [not reproduced] assume that castings of high-silicon iron can play an increasingly useful rôle, provided reliability can be assured. Experience with different qualities during the last twelve months has varied at different works. There have been fractures, in part due to faulty castings, in part due to thermal shock, and in some cases to a lack of appreciation of the provisions necessary to take up strains and stresses. There is urgent need for a high-silicon iron that can be welded and can form part of a hybrid structure. So important is the question of the manufacture of high-silicon iron, in its relationship to design of acid-concentrating plant, denitration, and nitric-acid manufacture, under hitherto unusual conditions, that the author offers no apology for dealing with the subject in some detail.

It is known that an association of manufacturers interested in the production of high-silicon iron castings has been formed, and that collaboration on technical questions is proposed. All this augurs well for the development of a technique which ultimately will lead to reliability. High-silicon irons as corrosion-resisting metals have been known for many years. Large quantities were manufactured during 1914-1918. Several varieties, such as Ironac, Meldrum metal, Narki and Tantiron, were made in this country during that period. The Continental qualities were Métillure (France), Neutraleisen (Germany) and Eleianite (Dr. Rossi, Italy). Duriron was manufactured in the United States of America.

It was fairly well established then that high-silicon iron, to possess satisfactory corrosion-resisting properties, should contain 14 per cent. of silicon. Fig. 3 broadly indicates corrosion resistance in relation to the percentage of silicon.

Since 1918 high-silicon irons have been made by several firms, but whether the same technique has been maintained as was practised during the period 1914 to 1918 is not definitely known. In any case, recent requirements, say since 1939, may have been more stringent than in 1914-1918.

What does not appear to have been adequately recognised is that the contents of carbon and phosphorus have an important bearing on the

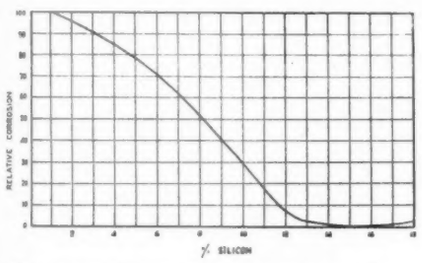


FIG. 3.—GRAPH SHOWING RELATION OF CORROSION TO SILICON CONTENT OF HIGH-SILICON IRONS.

suitability of the metal. Investigations have revealed gas inclusions, and that these may consist of hydrogen, acetylene and methane, possibly arising from the furnace gases during the preparation of the charge. These gas inclusions contain beads of a phosphide eutectic with about 6 per cent. of phosphorus.

It is generally accepted that the eutectic of the iron-carbon series of alloys is reached when the alloy has a total carbon content of 4.3 per cent. The alloy freezes at about 1,130 deg. C. Within the cupola, with the higher temperatures, the metal may contain more than 4.3 per cent. of carbon. Molten iron absorbs carbon readily within certain limits. It has been estimated that a saturated solution at 1,400 deg. C. contains about 6 per cent. of carbon. At higher temperatures more carbon may be dissolved. As the temperature of the metal is lowered to freezing point, carbide in excess of the eutectic amount is precipitated, and the carbide is dissociated with the liberation of iron and graphite and the formation of scum.

When silicon is added to the iron-carbon eutectic alloy, the solubility of the carbon is appreciably affected. Data obtained by Wüst and Petersen[2] from tests of silicon-iron-carbide alloys are given in Table V.

The curve in Fig. 4 represents in graphic form the data obtained in these investigations. What is significant is (*a*) the regular decrease in carbon content with successive increments of silicon, and (*b*) the equally regular rise in the freezing point.

Reference to Fletcher's Paper[3] reveals that for every 1 per cent. of silicon which is introduced into cast iron, 0.286 per cent. of carbon is thrown out of solution, and that for every 1 per cent. of phosphorus introduced, 0.387 per cent. of carbon is thrown out of solution, at or about the moment when solidification of the metal occurs.

The influence of manganese and sulphur on the solubility of carbon, in the small quantities which are present in the alloy under consideration, does not appear to be significant.

TABLE V.—*Tests of Silicon-Carbide-Iron Alloys.*

Test No.	Silicon. Per cent.	Total carbon. Per cent.	Freezing point. Deg. C.
1	0.13	4.29	1,138
2	0.21	4.23	1,131
3	0.66	4.05	1,156
4	1.14	3.96	1,155
5	1.41	3.88	1,160
6	2.07	3.79	1,175
7	2.68	3.56	1,185
8	3.25	3.41	1,187
9	3.69	3.32	1,197
10	3.96	3.24	1,205
11	4.86	3.08	1,210
12	5.06	2.86	1,215
13	13.54	1.94	1,223
14	18.76	1.19	1,240
15	26.93	0.87	1,255

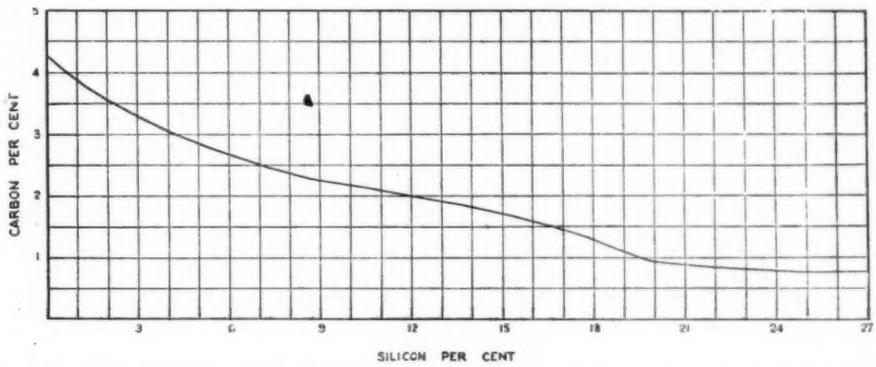


FIG. 4.—GRAPH SHOWING DECREASE OF CARBON CONTENT WITH INCREASE OF SILICON CONTENT.

The data obtained by Wüst, Petersen and Fletcher suggest that an alloy containing 14 per cent. of silicon and 0.2 per cent. of phosphorus would have, on freezing, a total carbon content of approximately 1.6 per cent. In a Paper read before the American Chemical Society, Williams and Sims[4] concluded that the presence of a large quantity of silicon decreases the amount of carbon dissolved in the frozen iron, but does not affect the amount of carbon which is absorbed and held in solution by the molten metal. This conclusion agrees with the observations of several other investigators, including Longden.

Influence of Composition

It seems to be accepted that in grey iron the silicon present causes the carbide constituent to break down into iron and graphite, leaving the phosphide structure free. Phosphorus has no appreciable effect on the condition of the carbon, but it reduces the solubility and thus acts indirectly as a hardener of the metal, particularly against abrasive wear. Since the phosphide eutectic is the constituent which has the lowest melting point, phosphorus promotes fluidity, and it is well known that high-phosphorus irons are well adapted for the manufacture of intricate work of small section. High-phosphorus castings, however, are very weak and brittle.

How far it is desirable to eliminate phosphorus appears to be a matter of some controversy. Silicon irons of low phosphorus content appear to possess a flaky structure—a condition that may also affect the temperature of pouring. It seems probable that it has been the practice during the last twenty years to ensure the presence of a certain amount of phosphorus as an aid to fluidity. There is, however, a tendency for new specifications to be formulated, and it is not improbable that the following figures may represent the chemical characteristics of Grade I high-silicon iron of the future:—Silicon, 14.5 to 15.5 per cent.; carbon, below 0.5; phosphorus, below 0.2; manganese, below 0.8; and sulphur, as low as possible, say not more than 0.05 per cent.

Matters for Research

Whether nickel should be used with a view to inhibiting the grain growth of silicon iron is a matter which is now being investigated. Perhaps the introduction of nickel may tend to decrease resistance to corrosion of the high-silicon iron.

It seems clear that the less carbon there is in the cast iron, or in the hematite iron, the better. Little, if indeed any, of the carbon enters into solution; it is practically all graphitic. Perhaps it is better to use steel with the ferro-silicon in the preparation of the high-silicon pig. It may be desirable to use an oil-heated or electrically-heated furnace. The use of a cupola, where the products of combustion from coke come into direct contact with the metal, is to be deprecated.

Should the ferro-silicon be introduced direct to the pig, or should a king alloy be prepared, with a view to obtaining a more homogeneous distribution of the ferro-silicon?

Apart from the preparation of the pig, and the care needed in the pouring of the casting, and the time of pouring, it may be expedient to submit the castings to a strain-relieving process. This involves the use of a coke-annealing furnace, raising the temperature to 900 to 1,000 deg. C. What is of primary importance is that the castings raised to this temperature should be cooled slowly, and certainly cooled uniformly.

Silicon-iron castings are not brittle when red-hot; the property of brittleness belongs to the cooled metal. This is an aspect that calls for

TABLE VI.—*Analytical Results for Typical English and American High-Silicon Iron.*[6]

(Figures for constituents as percentage of total weight.)

	English.	American.
Gr	0.75–1.25	—
T. C.	—	0.2–0.60
Si	14–15	14–14.5
Mn	2.0–2.5	0.25–0.35
S	0.05–0.15	Under 0.05
P	0.05–0.10	0.16–0.20
Melting-point, deg. C.	1,400	1,380–1,400
Tensile strength, tons per sq. in.	6–7	—
Compressive strength, tons per sq. in.	6–8	7

investigation, as any step that could be taken to avoid undue brittleness of the castings would be an achievement of importance. In a survey of high-silicon irons, Brian N. Reavell[5] has made pertinent observations calling for careful study.

Table VI gives analytical results for typical English and American high-silicon irons.

DISCUSSION

DR. M. W. TRAVERS, commenting that a great deal of work was being done in the development of silicon iron, said that for a long time that development had been the subject of study by various firms, who had been obliged, for reasons which were largely economic, to make use entirely of the cupola as a means of melting. Their process had always been to make first a mother alloy and then to melt for the second time to produce a better final product. In the early part of 1940, when he was in France, he had visited the Creusot works and had seen there the making of silicon iron in the pulverised-fuel-fired rotary furnace by the two-stage melting process. The mother alloy which was produced by the first melting was always blown, but the product of the second melting was sensibly free from blowholes and, as the makers were using a steel scrap and a 25 per cent. silicon iron produced in the foundries in the South of France, it was fairly free from phosphorus.

The oil-fired rotary furnace was being put to use in this country nowadays, and the Government was subsidising an installation in which silicon iron was being melted in the electric furnace. The problem of annealing was being studied by the Government research departments in conjunction with the National Physical Laboratory and with Prof. Bragg at Cambridge. It was hoped that many of the problems would be solved; but it must be remembered that, whilst the manufacture of silicon iron might be a science, there was behind it always the craft of the founder, and that was based upon long experience and a certain degree of artistry, which we could not possibly do without.

MR. S. J. TUNGAY, who has been in very close contact with the production of high-silicon irons during the last 30 years, assured Mr. Parrish that most of the reputable manufacturers of such irons were using a certain amount of steel as a source of raw material. Also, a normalising process was used by all reputable firms producing high-silicon irons at present. He had had some experience of the high-silicon iron produced at the Creusot works, and to a large extent those producers had had difficulties similar to those experienced in this country; their high-silicon irons were not free from gas inclusions or from the eutectic pellets. It was difficult to say whether or not a malleable high-silicon iron would ever be arrived at, but in his view it was extremely doubtful that it would.

A tremendous amount of research and experimental work had been devoted to the high-silicon irons and was still being devoted to them. He felt sure that the high-silicon irons produced in this country to-day were of far better quality than those produced 20 years ago, and he believed they would hold their own with the Continental; at any rate, Continental manufacturers had been obtaining supplies from this country very largely, a fact which indicated that the quality of the material they were obtaining here was quite equal to, if not better than, that obtainable in their own countries.

MR. A. B. SCORER, as a representative of perhaps the largest manufacturers of silicon iron in this country, who had been making the material for at least 30 years, said that during the last war his firm had been concerned very largely with the cascade type of acid concentration plant; during the present war they were concerned almost entirely with the pot type of plants, and the dephlegmators in those plants had stood up to their work very well indeed, on the whole. Quite a number had been working for 12 months or more and were still in perfect condition. He assured Mr. Parrish that the specification set out in the Paper could be met entirely, and that very shortly the metal would be melted in oil-fired furnaces as opposed to the cupola. However, it was quite possible to produce cupola metal almost carbon-free. There was a stage during the cooling of the metal at which practically all the carbon was given out in the form of graphite; that could be removed from the top of the molten metal, and there was a critical point in the pouring of the metal, dictated mainly by experience, at which a practically carbon-free metal could be obtained. That did not involve such great trouble as one might imagine. At the same time, there were advantages in the use of oil-fired and electric furnaces, to the benefit of the users of the metal.

Urging that it was possible for the designers of dephlegmators and similar plant, by collaboration with the manufacturers, to arrive at a much better design than was at first evolved, he emphasised that the manufacturers could offer a great many suggestions for improvement of the construction which were not apparent to a designer who had not experience of the manufacture of the metal. Experience gained in the foundry was of very great importance in the manufacture of the metal; a scientific man could state exactly what he wanted, but without the aid of the experience gained in the foundry some very poor results might be obtained frequently, even though every care was exercised. Long years of experience dictated certain requirements which were not apparent on the surface. On the whole, the metal produced in this country would compare with any produced on the Continent or in America, and everything possible was being done here to keep that branch of manufacture right in the forefront; it could be claimed confidently that we in this country were achieving that object fairly well.

MR. F. E. WARNER, who referred to the successful use of the drum type of concentrator, particularly in the recovery of acid from sludge acid in petroleum refineries, commented that Duriron was being used a good deal in connection with them in the United States and was not causing very much worry; in one plant, for instance, he had heard that there had been only one silicon iron breakage in 12 years.

Author's Reply

MR. PARRISH, in his reply, assured both Mr. Tungay and Mr. Scorer that he was not attempting to make an attack on the manufacturers of silicon iron. He had some silicon iron which was supplied 27 years ago, and which was still as good as when it was new; and he had another brand which had been in use for 10 years and was still operating as well as it was 10 years ago. On the other hand, there had been failures, and one was asked to explain them from time to time. He was perfectly certain there was a need for improvement, and apparently one firm was already proceeding on well-defined and scientific lines to improve the quality of its material. This country could not have done without the two leading firms, which had been largely responsible for the large production of high-silicon irons here.

REFERENCES.

[1] "Sulphuric Acid Concentration (Parrish and Snelling). Ernest Benn, Limited, London, 1924. Vol. II.—"In Heated Vessels."

[2] J. Longden, FOUNDRY TRADE JOURNAL, December 7, 1922.

[3] "Blast Furnace and the Foundry Cupola," FOUNDRY TRADE JOURNAL, March 30, 1922.

[4] FOUNDRY TRADE JOURNAL, August 3, 1922.

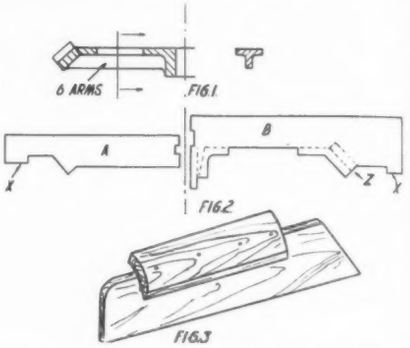
[5] "Chemical Age," Metallurgical Section, May 4, 1940.

[6] Mason ("Kempe's Engineering Hand Book")

Some Jobbing Foundry Experiences—XVIII

By "TRAMP"

Bevel gears are not cast so extensively now as formerly, but occasions still arise when repairs or renewals necessitate their manufacture. In shops equipped with wheel moulding machines their production is a fairly simple matter, but when large wheels are required from jobbing shops the method of sweeping has to be resorted to. Fig. 1 is a sketch of a typical wheel. The



sweeping boards necessary for the mould are shown in Fig. 2. A tooth block would be used to form the teeth on the face swept by board A, while six pattern arms as shown in Fig. 3 are built into the bottom swept by board B. On assembly a "crush" is liable to occur, so face Z is swept $\frac{1}{8}$ in. clear so that the teeth are not damaged on closing. Guides X are used to facilitate positioning.

Catalogues Received

Aluminium Alloys. Under the title, "Hiduminium Technical Data," High Duty Alloys, Limited, of the Trading Estate, Slough, have published in a particularly attractive form an entirely new set of data sheets. By utilising a spiral binding, it has been found possible to display on facing pages the complete data of any one alloy in such a manner as to make what amounts to one flat surface. The opening sheets list the standard specifications and correlate them with the brands entering within the Hiduminium alloy series. Those which follow deal with 15 types of forging and casting alloys. The data given are particularly complete, whether they relate to castings or forgings. In the former case, for example, both the linear and patternmakers' contractions are given. This valuable publication, which the issuing house has kindly made available to our readers, can be had on applying to Slough.

Cable Vulcanisers. Harvey, Frost & Company, Limited, of Bishops Stortford, have sent us a folder which illustrates and describes both portable and fixed tools designed to effect rapid and efficient vulcanising when joining or repairing cables. This obviously useful tool converts improvisation into a simple workmanlike process. With the portable tool the heating is by means of solid-fuel tablets, whilst electric heating is provided for the workshop model.

Enamel Thickness and Opacity

According to a review of "Tin Oxide Opacifiers in Vitreous Enamels" in "Tin and Its Uses," a 25 per cent. increase in enamel thickness was required to give a 27 per cent. increase in opacity. By increasing the proportion of opacifier from 4 to 8 per cent., the thickness required to give a reflectance value of 70 could be reduced from 0.0167 in. to 0.0106 in., *i.e.*, to 63.5 per cent. of its original thickness.

Metallography of Inclusions in Cast Irons and Pig-Irons

By H. MORROGH (British Cast Iron Research Association, Birmingham)

(*Continued from page* 90.)

Group III.—White or Faint Grey Inclusions

(*a*) *Idiomorphic Inclusions, and* (*b*) *Allotriomorphic Inclusions*

The inclusions belonging to these sub-groups appear in all titaniferous irons and in irons containing vanadium. Hofmann and Schrader[83] observed that alloying ferro-titanium with cast iron produced a hard, cubic, greyish-white structural "constituent." This was separated from the alloy by solution of the iron in cold dilute hydrochloric acid and recognised as titanium carbide by X-ray analysis. Usually, titanium carbide occurs in the form of cubic crystals (Figs. 42 and 48), but occasionally it occurs in an allotriomorphic form (Figs. 50 and 51). This latter form occurs most frequently in titaniferous irons containing very small amounts of vanadium. For instance, the pig-iron from which the micrographs in Figs. 50 and 51 were taken had the following analysis:—T.C, 3.8; Si, 1.64; Mn, 0.76; S, 0.033; P, 0.038; Ti, 0.15; and V, 0.02 per cent.

Both titanium carbide and vanadium carbide[31] have cubic crystal structures, and in irons containing both titanium and vanadium these two carbides appear to crystallise isomorphously or to yield solid solutions. The pig-iron used for melts Nos. 3 to 11, in the previous section of this Paper, contained 0.60 per cent. of titanium and 0.50 per cent. of vanadium, and its microstructure showed hard cubic crystals apparently all of the same type.

The number of titanium carbide crystals present in irons of different cross-sectional dimensions varies inversely as the cross-section for irons with the same titanium content. This was proved by the following experiment: A charge of 45 lbs. of pig-iron and 15 lbs. of steel was melted in a salamander crucible, using a coke-fired, forced-draft furnace. The pig-iron had the following composition:—T.C, 4.04; Si, 2.19; Mn, 1.10; S, 0.010; P, 0.048; and Ti, 0.06 per cent. When the charge was molten, a set of standard test-bars, 0.6 in., 0.875 in., 1.2 in., 1.6 in. and 2.1 in. in dia., was cast, having the lengths 10 in., 14 in., 21 in., 21 in. and 27 in. respectively. Each of these bars was broken in transverse, and metallographic samples were taken from the bars at the points of fracture, *i.e.*, approximately half-way along the original bars. The micro-specimens were then examined with a 2-mm. oil-immersion objective, using a 10× eye-piece at a magnification of 1,676 diameters. The number of titanium carbide and titanium nitride inclusions per unit field was counted for two hundred fields and the average number of these inclusions per unit field was then calculated for each bar. The titanium content of these bars was 0.05 per cent. The results of the inclusion counts are given in Table IV.

This variation of the number of titanium carbide crystals with the test-bar diameter may seem strange at first, but it should be remembered that such a variation is the general rule for the constituents of the cast-iron microstructure. For instance, in grey irons smaller sections show finer, and hence more numerous, graphite flakes, and for a given area of pearlite the number of cementite lamellæ will tend to increase. It is interesting to note that variations in test-bar diameter have much less effect on the number of titanium cyano-nitride crystals than on the number of titanium carbide crystals.

With increasing titanium contents the number of titanium carbide crystals increases, as also does the size of the individual crystals. The results of inclusion counts illustrating the combined effects of variations in test-bar diameter and titanium content on the number of titanium carbide and cyano-nitride crystals are given in Table V.

The higher titanium contents were obtained by the addition of 4, 6, and 8 ozs. of ferro-silicon-titanium to charges of pig-iron and steel, as used for the first member of the series. It is seen that the number of titanium cyano-nitride crystals does not vary uniformly, as does the number of titanium carbide crystals. This is to be expected, since, for a given titanium content, the number of titanium cyano-nitride crystals must be a function of the nitrogen content of the metal, and it was not possible to control this factor during these experiments.

The equilibrium diagrams given by Tofaute and Büttinghaus[84] for the ternary system iron-carbon-titanium indicate titanium carbide to be appreciably soluble in austenite and, for hypo-eutectic alloys, completely soluble in molten iron. The following experiment was carried out in an attempt to determine whether the solubility of titanium carbide in austenite could be detected by inclusion counts for the temperature range 800 to 1,000 deg. C. To do this, sections, each 2 cm. long, were cut from a 0.875-in. dia. bar, containing 0.06 per cent. of titanium, and each section was annealed for 1 hr. at a constant temperature and quenched in water. The samples were cross-sectioned and polished, and the number of titanium carbide and titanium cyano-nitride crystals was counted, using the

FIG. 50. — ALLOTRIOMORPHIC FORM OF TITANIUM CARBIDE IN PIG-IRON. 2-MM. OIL-IMMERSION OBJECTIVE. UNETCHED. × 1,000.

FIG. 51.—ANOTHER ALLOTRIOMORPHIC FORM OF TITANIUM CARBIDE IN SAME PIG AS FIG. 50. 2-MM. OIL-IMMERSION OBJECTIVE. UNETCHED. × 1,000.

TABLE IV.—*Effect of Test-Bar Diameter on the Number of Titanium Carbide and Titanium Cyano-Nitride Inclusions*

Diameter of test-bar :	2.1 in.	1.6 in.	1.2 in.	0.875 in.	0.6 in.
Number of titanium carbide inclusions per unit field	0.385	0.515	0.645	0.925	1.195
Number of titanium cyano-nitride inclusions per unit field	0.130	0.165	0.230	0.170	0.315
Total number of titanium inclusions per unit field	0.515	0.680	0.875	1.095	1.510

TABLE V.—*Combined Effects of Test-Bar Diameter and Titanium Content on the Number of Titanium Carbide and Titanium Cyano-Nitride Inclusions.*

Titanium :	0.05 per cent.			0.07 per cent.		
Test-bar diameter :	2.1 in.	1.6 in.	1.2 in.	2.1 in.	1.6 in.	1.2 in.
Number of titanium cyano-nitride inclusions	0.130	0.165	0.230	0.57	0.605	0.56
Number of titanium carbide inclusions	0.385	0.515	0.645	0.96	1.145	1.305
Total number of titanium inclusions	0.515	0.680	0.875	1.53	1.750	1.865
Titanium :	**0.095 per cent.**			**0.105 per cent.**		
Test-bar diameter :	**2.1 in.**	**1.6 in.**	**1.2 in.**	**2.1 in.**	**1.6 in.**	**1.2 in.**
Number of titanium cyano-nitride inclusions	0.76	0.68	1.21	0.505	0.425	0.22
Number of titanium carbide inclusions	1.32	1.595	2.47	1.915	2.405	3.61
Total number of titanium inclusions	2.08	2.275	3.68	2.42	2.83	3.83

same method as for the other experiments in this part of the Paper. The results obtained are given in Table VI. While it is impossible to deduce anything very definite from these results, they do seem to indicate a slight decrease in the number of titanium carbide crystals on raising the temperature from 825 to 1,000 deg. C.

TABLE VI.—*Effect of Quenching Temperature on the Number of Titanium Carbide and Titanium Cyano-Nitride Inclusions.*

Temp. Deg. C.	Average number of inclusions per unit field.		
	TiC.	$Ti_2(C,N)_2$.	TiC + $Ti_2(C,N)_2$.
1,000 ..	0.855	0.145	1.00
975 ..	0.62	0.31	0.93
950 ..	0.67	0.295	0.965
925 ..	1.055	0.19	1.245
900 ..	1.02	0.16	1.18
875 ..	1.16	0.225	1.385
850 ..	1.27	0.225	1.495
825 ..	1.22	0.145	1.365

It would appear that the number of titanium cyano-nitride crystals remains constant over this temperature range. The solution of the titanium carbide would be very difficult to observe with higher titanium contents, because the decrease in size of the crystals consequent on the solution of the carbide would not be sufficient to effect a measurable decrease in the number of crystals.

The results of the inclusion counts presented so far in this Paper must be recognised as having little, if any, quantitative significance; they indicate only the general tendencies with regard to the behaviour of titanium carbide.

FIG. 52. — TYPICAL ORANGE-YELLOW TO GREY INCLUSION IN BAR Z2.

FIG. 53. — COMBINATION OF TWO LAMELLAR ORANGE-YELLOW TO GREY ZIRCONIUM INCLUSIONS.

FIG. 54. — ORANGE-YELLOW TO GREY INCLUSION THROUGH TITANIUM CARBIDE CRYSTAL.

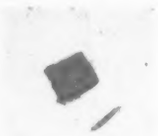


FIG. 55.—ZIRCONIUM CYANO - NITRIDE CRYSTAL WITH CORED STRUCTURE.

FIG. 56. — TITANIUM CARBIDE CRYSTAL WITH CENTRE OF ZIRCONIUM CARBIDE.

FIGS. 52 TO 56.—2-MM. OIL-IMMERSION OBJECTIVE. UNETCHED. × 1,200.

FIG. 57.—2-MM. OIL-IMMERSION OBJECTIVE. UNETCHED. × 1,200.

FIG. 58.—SAME SPOT AS FIG. 57 AFTER ROTATION OF STAGE THROUGH 90 DEG.

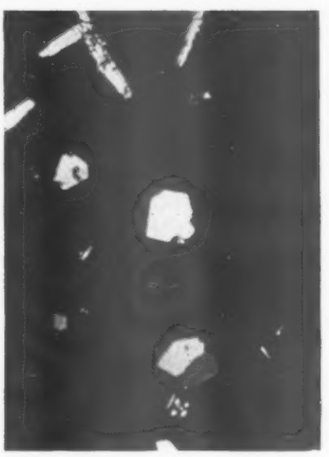


FIG. 59.—SAME SPOT AS FIGS. 57 AND 58 BETWEEN CROSSED NICOLS.

FIGS. 57 TO 59.—ORANGE-YELLOW TO GREY INCLUSIONS SURROUNDED BY SEGREGATION OF BLUE-GREY ZIRCONIUM CUBES.

Group IV.—Inclusions Produced by Alloying with Zirconium

Zirconium is rarely added to cast iron, but its effects can be conveniently dealt with here, since the element itself shows considerable chemical similarity to titanium. Furthermore, the inclusions introduced into cast iron by zirconium in many ways resemble those introduced by the presence of titanium and, in at least one case, the two elements combine together to give a complex constituent. Nearly all cast irons contain small amounts of titanium, and so the effects of zirconium additions to cast irons are indissolubly associated with the effects of any titanium which is present.

There is practically no information in the literature on the precise effect of zirconium on the microstructure and inclusions of cast iron. However, there is some published information on the effect of this element on the inclusions in steels, and it is useful here to consider a brief review of this work. Field[55] found that when deoxidising steel with silicon-zirconium, a considerable proportion of the zirconium was lost—the average yield of zirconium was 59.7 per cent., while that of silicon from the same additions was 97 per cent.

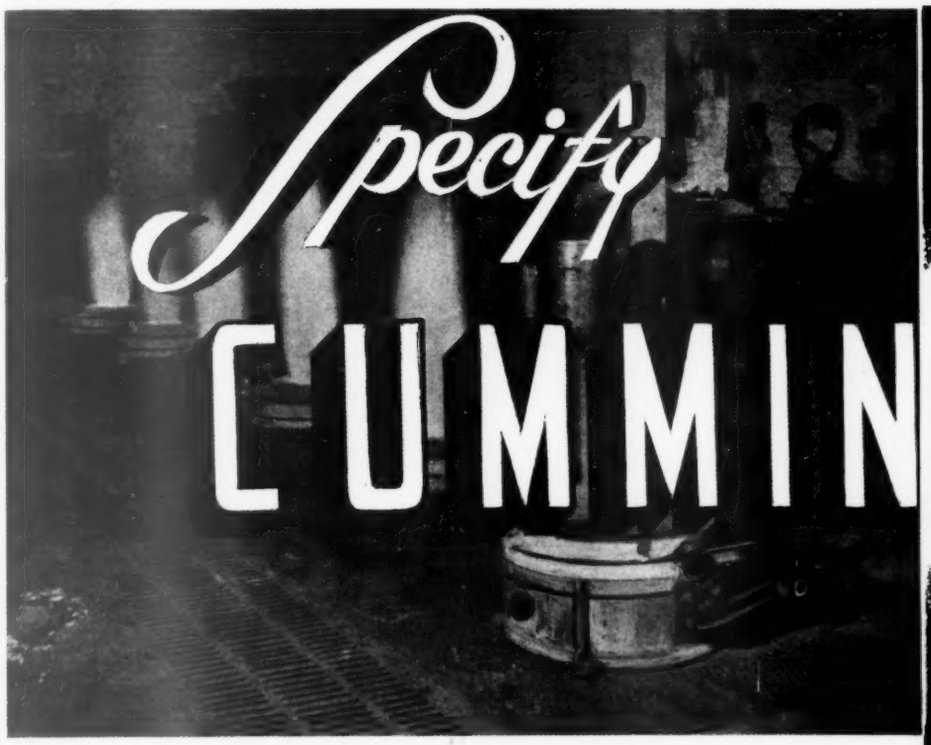
This investigator claimed that zirconium combined with oxygen, nitrogen and sulphur in the order given, and he was able to show that zirconium additions resulted in the formation of a bright lemon-yellow nitride. In another Paper, Field[56] points out that zirconium forms a sulphide very similar in colour to manganese sulphide, and he found that additions of zirconium removed red-shortness from steel when the finished product had a ratio of zirconium to sulphur equal to 1.41:1. Furthermore, he claimed that this ratio corresponded to the formation of the compound ZrS_2.

Urban and Chipman[45] found that additions of zirconium to sulphurised iron resulted in the formation of inclusions varying in colour from tan to grey. They found the tan inclusions to be anisotropic and the grey inclusions isotropic, and suggested that the sulphides observed by Field were manganese sulphide, perhaps contaminated with zirconium. These inclusions, they say, were angular or crystalline in outline and were not affected by annealing or forging.

The findings of Urban and Chipman were substantially confirmed by Portevin and Castro,[45] who found that the addition of 0.89 per cent. of zirconium to remelted Swedish iron gave yellowish-grey sulphide inclusions which were markedly anistropic. They suggest that this phase replaces the sulphide of manganese (and zirconium) when the percentage of zirconium is sufficiently high. These investigators also describe the occurrence of blue-grey zirconium carbide, lemon-yellow zirconium nitride and zirconium cyano-nitrides ranging in colour from lemon-yellow or orange-brown to purple, violet and blue in one crystal. Both zirconium carbide[57] and zirconium nitride[58] have cubic crystal structures, and Portevin and Castro suggest that the solutions involved in the zirconium cyano-nitride crystals are continuous solid solutions of the system ZrN-ZrC.

It would thus appear from this review that additions of zirconium to cast irons might cause the appearance of zirconium sulphide, nitride, carbide and cyano-nitride phases. To determine the effect of zirconium on inclusions in cast iron, a series of irons having increasing zirconium contents was examined. These irons were prepared by melting a hematite base iron in a 250-lb. oil-fired crucible furnace. When molten, the requisite amount of metal was tapped into a handshank, and the alloy additions were made while the metal was in the shank. The zirconium was added in the form of ferro-silicon-zirconium having the following analysis:—Zr 38.8, Si 50.00, and Fe 8.25 per cent.

Bars 1.2 in. in dia. from eleven such irons were examined, having zirconium contents ranging from 0.04 to 0.54 per cent. These bars have been numbered Z1 to Z11. Bars Z1, Z2, Z3 and Z9 were made from a base iron having 3.5 per cent. of total carbon and 1.4 per cent. of silicon, bars Z4, Z5, Z8 and Z11 from a base



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iron having 2.9 per cent. of total carbon and 2.2 per cent. of silicon, and bars Z6, Z7 and Z10 from a base iron having 3.3 per cent. of total carbon and 1.7 per cent. of silicon. In every case the addition was either ½, 1, 1½ or 2 lbs., which was added to about 28 lbs. of the base iron. The analyses and alloy additions used are given in Table VII, which also indicates the types of inclusions met with in these bars. A more detailed description of the inclusions is given below.

Bar Z1, Zirconium 0.04 per cent.—Titanium carbide cubes and manganese sulphide crystals are the only inclusions present in this bar.

Bar Z2, Zirconium 0.05 per cent.—This bar contained titanium carbide and a small amount of manganese sulphide, as in bar Z1. Also present were a number of orange-yellow to grey lamellar inclusions, a typical example of which is shown in Fig. 52. These inclusions are presumably the same as those described by Urban and Chipman and by Portevin and Castro. Close examination revealed these inclusions to be pleochroic, which explains why their colour varied from orange-yellow to grey. When such an inclusion lies parallel to the plane of polarisation of the incident light it appears orange-yellow, and when, after a rotation of the microscope stage, it lies at right angles to the plane of polarisation of the incident light it appears light grey. The plane polarised light produced by reflection from the glass slip of the vertical illuminator is quite sufficient to enable the easy detection of this reflex pleochroism, the use of a polariser merely heightening the colour contrast in these two positions. The presence of the pleochroic effect in these inclusions has not been detected by previous investigators, and it explains why Portevin and Castro gave the colour of them as "yellowish-grey." When examined under polarised light between crossed nicols, they were found to be markedly anisotropic.

TABLE VII.—*Effect of Zirconium on the Inclusions in Cast Iron.*
The presence of a constituent is indicated thus: ×.

Bar no.	Chemical analysis. Per cent.							Weight of alloy addition. Lbs.	TiC, white-grey.	(Ti,Zr)C, pinkish.	MnS, dove-grey.	ZrC, blue-grey.	Orange-yellow to grey inclusion.		Cored cyano-nitride.
	T.C.	Si.	Mn.	S.	P.	Ti.	Zr.						Lamellar.	Polygonal	
Z1	3.39	1.45	0.80	0.021	0.061	0.06	0.04	½	×	—	×	—	—	—	—
Z2	3.51	1.53					0.05	1	×	—	×	—	×	—	—
Z3	3.42	2.05					0.09	1½	×	—	—	—	×	—	—
Z4	2.91	2.24	0.81	0.017	0.035	0.08	0.12	½	×	—	—	—	×	—	—
Z5	2.87	2.60					0.13	1	×	—	—	×	×	—	—
Z6	3.21	1.79	0.55	0.030	0.048	0.07	0.15	½	×	—	—	×	×	×	×
Z7	3.23	1.95					0.16	1	×	—	—	×	×	×	×
Z8	2.67	2.74					0.16	1½	×	—	—	×	×	×	×
Z9	3.45	2.47					0.25	2	×	×	—	×	—	×	—
Z10	3.17	2.45					0.29	1½	—	×	—	×	—	×	—
Z11	2.74	3.51					0.54	2	—	×	—	×	—	×	—

The orange-yellow to grey inclusions, while frequently lamellar themselves, have other lamellæ growing out of them, forming re-entrant angles (Fig. 53), and occasionally they occur cutting straight across titanium carbide crystals (Fig. 54).

Bar Z3, Zirconium 0.09 per cent.—This bar contains titanium carbide as in the two previous bars, but no manganese sulphide is present. This constituent appears to have been completely replaced by the lamellar orange-yellow to grey zirconium inclusion.

Bar Z4, Zirconium 0.12 per cent.—The inclusions in this bar are essentially similar to those in Z3.

Bar Z5, Zirconium 0.13 per cent.—This bar contains titanium carbide as in the previous bars, but there is much more of the orange-yellow to grey inclusion, the lamellar form of which is partly replaced by a polygonal form. Also present are some blue-grey cubic inclusions which are isotropic. These latter appear to be the same as those described by Portevin and Castro as zirconium carbide.

Bar Z6, Zirconium 0.15 per cent.—This bar is very similar to Z5, but the polygonal orange-yellow to grey inclusion is more in evidence, as is the cubic carbide inclusion. Titanium carbide is still present. A few crystals of the zirconium cyano-nitride are present in this sample. These crystals usually have a series of concentric rings ranging in colour from red-pink to deep purple. A typical crystal showing the concentric rings is illustrated in Fig. 55; the main body of the crystal is red-pink and the two dark rings are deep purple.

Bar Z7, Zirconium 0.16, and Bar Z8, Zirconium 0.16 per cent.—With regard to inclusions, these bars are identical. They show titanium carbide, polygonal orange-yellow to grey zirconium inclusions with a trace of the lamellar form, the blue-grey zirconium carbide and traces of the cored cyano-nitride.

Bar Z9, Zirconium 0.25 per cent.—In this bar the lamellar orange-yellow to grey inclusion has been completely replaced by its polygonal form. The titanium carbide present has a definite pinkish appearance, and occasionally crystals of this phase can be seen to have crystallised around zirconium carbide cubes. This effect makes the centres of the titanium carbide crystals appear softer. An attempt has been made in Fig. 56 to show a titanium carbide crystal with a darkish centre of the zirconium carbide. The free zirconium carbide crystals tend to occur in large segregations. The individual crystals of this phase are usually very small and difficult to photograph. Fig. 57 shows a group of fairly large orange-yellow to grey inclusions surrounded by a segregation of the blue-grey zirconium carbide cubes. The apparently dark polygonal crystals were actually orange-yellow and the light crystal was grey in the particular stage position used. Fig. 58 depicts the same spot after rotating the stage through 90 deg.; the inclusion which was formerly light (grey) is now dark (orange-yellow), while some of the inclusions which were formerly dark (orange-yellow) are now light (grey). Fig. 59 shows the same spot under polarised light between crossed nicols. The anisotropic character of the polygonal orange-yellow to grey inclusions is clearly seen, while the small carbide cubes have remained dark.

Bar Z10, Zirconium 0.29 per cent.—This bar is essentially similar to Z9, but all the titanium carbide has been replaced by the faint pinkish phase, which is presumably a carbide of the type $(Ti,Zr)_2C_2$.

(To be continued.)

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[54] Tofaute and Büttinghaus: "Archiv für das Eisenhüttenwesen," 1938, vol. 12, p. 33.
[55] Field: Trans. A.I.M.M.E., 1923, vol. 69, p. 848.
[56] Field: Trans. A.I.M.M.E., 1924, vol. 70, p. 201.
[57] Friedrich and Sittig: "Zeitschrift für anorganische und allgemeine Chemie," 1925, vol. 144, p. 71.
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Special and Alloy Steels

(*Continued from page* 105.)

revolutionised their properties and potential applications. He would go further and say that many of the engineering feats of the present war would have been quite impracticable and impossible had that metallurgical development not taken place.

His reason for placing this matter before them was really to give them ground for hope. In this war they were all, their companies and themselves as individuals, pooling all that they knew and all that they had, with the one object of focusing everything that was possible to assist in making as efficient a fighting force as they could. This pooling of everything was the nearest approximation that he knew to the ideal state of society that was frequently dreamed of.

Post-War Years

But when peace came again they would resuscitate at any rate some of the aspects of the commercial world in which they lived previously, and it seemed to him—he was not talking merely about the internal affairs of this country but also of other countries—that as they made such colossal progress in their own particular branch of technology between 1918 and the present war, it was clearly indicated, and their present experimental work would confirm the view, that when they got down to the normal pursuit of scientific and technical inquiry again they would produce, in the decades that were to come, equal or perhaps greater advances than they achieved from 1918 to the present war.

He trusted that what he had put before the meeting disclosed quite a healthy state on the part of British special steel metallurgy at the present time, and they would judge from what he had said that they were likely to be able to continue their "pastime." Should circumstances develop which required a little thought, deduction and rearrangement, he was quite sure that his colleagues in the industry would be quite equal to any task that might be imposed upon them.

PROF. J. H. ANDREW proposed a vote of thanks to Dr. Hatfield, and DR. T. SWINDEN seconded.

Two New B.S. Standards

The British Standards Institution, 28, Victoria Street, London, S.W.1, has recently issued two fresh war emergency specifications of interest to an important section of the non-ferrous foundry trade. No. 920 covers Naval Brass Die-Castings, and information is given as to compositional limits; the provision of test-pieces; manufacture; defects, and mechanical-test performances. No. 932 relates to Brass Gravity Die-Castings, the general treatment being similar to No. 920. They cost 2s. 3d. each, post free.

Manganal

Manganal, an austenitic, tough, non-magnetic steel containing 11 to 13½ per cent. manganese and 3½ per cent. nickel, is now being marketed by the American manufacturers. This non-magnetic, abrasion-resisting steel, which can be welded, permits weight to be saved in building composite structures by welding castings and Manganal plates, using Manganal only where necessary for wear resistance. Manganal is said to have all the advantages of 11 to 14 per cent. manganese steel in resistance to wear and surface work-hardening. Thicknesses up to ½ in. can be sheared. The chemical composition and the physical properties of Manganal are:—Carbon, 0.60 to 0.90; manganese, 11 to 13½; silicon, 0.60 to 0.95; nickel, 2.50 to 3.50 per cent. The tensile strength is 62 to 67 tons per sq. in.; elastic limit is 24.5 to 27 tons per sq. in.; elongation in 2 in. is 72 per cent.; and reduction of area is 54 per cent. Typical applications include journal boxes, pedestal liners, wear plates, mill liners, shovel buckets, conveyors, crusher hammers, etc. This steel is available in 48-in. by 120-in. plates in the following thicknesses: 3/16, ¼, ⅜, ½, ⅝, ¾ and 1 in.—"Iron Age."

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ACCIDENTS INCREASE as TEMPERATURES SOAR

A high accident rate often indicates want of proper thought — not by the workers — but by the employer. It indicates, more often than not, failure to provide against bad atmospheric conditions which cause undue fatigue, loss of concentration, and reduced efficiency. The Government's Emergency Report No. 1, "Industrial Health in War," states :—

". . . accidents are relatively frequent at . . . high air temperatures, but relatively few at intermediate temperatures." This publication also states : ". . . where ventilation has been interfered with by black-out conditions, special provision for ventilation is urgent . . lest the efficiency and comfort of the workers should become impaired."

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The Week's News in Brief

Trade Talk

THE ADDRESS of the British Aluminium Company, Limited, is now Oakley Manor, Belle Vue, Shrewsbury, Shropshire.

EMPLOYEES of Harland & Wolff, Limited, Diesel Engine Works, Finnieston, Glasgow, contributed £604 to local hospitals and charitable institutions during 1940.

THE GENERAL COUNCIL of the Trades Union Congress has recommended the unions to join immediately with the employers' organisations in their industries in working out voluntary schemes for the organisation of man-power.

INQUIRIES regarding Purchase Tax to the head office of H.M. Customs and Excise should in future be addressed to The Secretaries, H.M. Customs and Excise, City Gate House, 39/45, Finsbury Square, E.C.2. The telephone number is Bishopsgate 6550.

FOLLOWING A MEETING of the Welsh Engineers and Founders' Conciliation Board, craftsmen in the trade are to have an increase in their wages of 5s. 6d. per week and labourers of 3s. 9d. per week. The increases date from December 2 and incorporate those granted some time ago.

THE NEWCOMEN SOCIETY met in London yesterday (February 12). A Paper was presented by Mr. A. F. Dufton on "The Early Application of Engineering to the Warming of Buildings," and Mr. C. E. Pearson dealt with "The History of the Hydraulic Extrusion Process for Metals."

MANCHESTER ASSOCIATION OF ENGINEERS has cancelled its plans for an annual dinner, and is arranging instead a "tea dance," to be held in Manchester on Saturday, March 15, from 2.45 to 6 p.m. Details are obtainable from the assistant secretary at St. John Street Chambers, Deansgate, Manchester.

FIGURES compiled by Jordan & Sons, Limited, show that of the 6,084 new companies registered in 1940 in England and Wales, no less than 706—over 11 per cent. of the total—were formed to carry on some engineering process, while in the previous year the "engineers" registered only 8 per cent. of the total. The 706 companies had a total capital of £2,778,855. Under the heading "Metals," 116 companies with capital totalling £287,746 were registered, while 68 new companies in the "Mines and Quarries" section had an aggregate capital of £172,201.

THE GENERAL COMMITTEE of Lloyd's Register of Shipping offers a scholarship, valued at £100 per annum and tenable for three years, to be awarded in May next, on the results of a competitive examination to be held by the Institute of Marine Engineers. The age limit for the scholarship, which is intended to assist marine engineering students to take a university course in engineering subjects, is 18 to 23 years, and the closing date for entries is April 8. The Secretary of the Institute of Marine Engineers, 73, Amersham Road, High Wycombe, Bucks, will supply further particulars and entrance forms.

A SHORTAGE of iron and steel supplies and increasing unemployment in the metal and building industries as a result thereof are reported from Switzerland. The outlook for a resumption of adequate imports to cover the demand does not appear good, and it seems possible that as a first step to alleviate the present position railings and metal armaments may be requisitioned. Old railway tracks no longer in use and scheduled for scrapping may also be torn up prematurely. Dr. Marbach, of Berne University, in an article reviewing the situation, recommends the establishment of facilities for handling domestic scrap supplies.

THE American steel industry itself can supply approximately 75 per cent. of the tonnage of raw materials which it consumes in a year of peak operations, and can purchase from domestic sources all but a fraction of its remaining raw material needs, concludes the American Iron and Steel Institute. Foreign sources of supply are required for less than one-half of 1 per cent. of the total tonnage of raw materials consumed annually. Those materials which must be purchased abroad, however, are essential in steel operations, and no completely adequate substitutes or sources have yet been developed; these include manganese, tin, palm oil, certain heat-resisting materials, and some metals used in alloy steels.

SINCE 1934 about 1,000 employees of the four works of Joseph Sankey & Sons, Limited, Bilston, have completed 20 or more years' service. Presenting long-service awards at the tenth annual prize distribution, Colonel H. B. Sankey, chairman of directors, questioned whether any industrial concern in the whole of the world could beat this record. In the last seven years 22 employees had completed 50 years; 95, 40 years; 233, 30 years; and 606, 20 years—956 employees with a total service of 24,010 years. At the distribution there were four recipients of a gold watch and £5 for 50 years; a gold badge and £4 for 11 for 40 years; a silver badge for men or silver brooch for women and £3 for 24 for 30 years. For 20 years' service, 44 employees received bronze badges or brooches and £2 each. In 1940, therefore, 83 employees, with a total of 2,240 years' service completed 20 years or more.

MR. ERNEST BEVIN, Minister of Labour and National Service, has decided on a reorganisation among his chief lieutenants as part of his plans for carrying out the new man-power programme. The Chief Industrial Commissioner, Mr. F. W. Leggett, will take charge of the departments dealing with welfare and the administration of the Factories Acts, as well as the Industrial Relations Department. He will be assisted by two Industrial Commissioners, Mr. R. Lloyd Roberts, whose services have been made available by Imperial Chemical Industries, Limited, and Mr. J. C. Little, formerly president of the Amalgamated Engineering Union, and more recently a director of labour supply at the Ministry of Labour. The object of the reorganisation is to place under one direction the related problems affecting wages and working conditions, and of welfare inside and outside the factories, which may arise through the transfer of large numbers of men and women in connection with the Minister's new proposals.

Personal

MR. JOHN OSWALD, secretary of Federated Foundries, Limited, has been co-opted a director.

MR. J. A. MILNE has been appointed general manager of J. Samuel White & Company, Limited, shipbuilders and engineers, and has commenced duties with the company.

MR. R. J. HATTO, sales director of S. Wolf & Company, Limited, manufacturers of portable electric tools, of Pioneer Works, Ealing, has been appointed general manager.

MR. G. PARKIN has been appointed head of the metallurgical laboratory and research department of Edward Pryor & Son, Limited, of Sheffield, makers of steel type marking devices.

MAJOR-GENERAL K. C. APPLEYARD, C.B.E., managing director of the Birtley Company, Limited, and a Past-President of the Newcastle Branch of the Institute of British Foundrymen, has been appointed Director of Emergency Reconstruction, an office created by the Minister of Works and Buildings.

MR. A. S. MACLELLAND, Director-General of Ammunition Production, is returning to the shipbuilding industry. In view of the heavy programme of naval and mercantile construction and repair the Board of Admiralty has asked the Minister of Supply to release Mr. MacLelland from his official duties. The Minister has agreed and Mr. MacLelland will return to his firm, Alexander Stephen & Sons, Limited, shipbuilders and engineers.

MR. JOHN BELL, who has been hon. secretary of the Scottish Branch of the Institute of British Foundrymen for 17 years, was presented with the Meritorious Services Medal of the Institute on February 8. The medal was handed over by Mr. H. Winterton, Past-President of the Institute, in the Royal Technical College, Glasgow. The Scottish Branch of the Institute has presented Mr. Bell with a grandmother clock and some Defence Bonds in recognition of the honour bestowed upon him.

MR. EDWARD HERBERT CLIFFORD has been elected President of the Institution of Mining and Metallurgy for the year 1941-42, taking office in May. Mr. Clifford, who was educated at St. Paul's School and received his technical training at the Royal School of Mines and the Freiberg Bergakademie, began his mining career on the Witwatersrand in 1897, and worked continuously in South Africa until the last war. He has managed various mines and in 1914 was appointed consulting engineer in Johannesburg to the Central Mining-Rand Mines Group. During the war Mr. Clifford joined the Mineral Resources Department of the Ministry of Munitions, of which he became chief technical adviser, and at the end of hostilities he resumed his former appointment with the Central Mining Group in South Africa, from which he resigned in 1922. Mr. Clifford was recently co-opted as a member of the Departmental Committee set up by the Ministry of Supply to inquire into the possible increased production of non-ferrous ores in the United Kingdom.

Will

ROBERTSON, WILLIAM, of Bearsden, Dumbartonshire, commercial manager of William Jacks & Company, Limited, iron, steel, and metal merchants £4,738

Obituary

THE DEATH occurred at Helensburgh on February 3 of Mr. Thomas Holden, late of D. & W. Henderson & Company, Limited, ship repairers, of Partick, Glasgow.

MR. GEORGE HENRY CROWTHER, for over 36 years proprietor of Crowther's Foundry, Bury New Road, Prestwich, has died at the age of 87 years, after 60 years' active association with the ironfounding industry.

MR. ARTHUR J. ENTWISLE, formerly connected with the family business of Entwisle & Gass, of the Atlas Foundry, Bolton, has died in his 92nd year. He was appointed to the Borough Bench in 1904, and celebrated his golden wedding six years ago.

MR. CLARENCE D. SMITH died at his home at Hexham, Northumberland, on February 3. A director of Smith's Dock Company, Limited, at the time of his death, he had been chairman of the Consett Iron Company, Limited, and on the board of the London & North Eastern Railway Company, among other companies.

MR. DAVID REES JONES died recently at his home at Morriston, Swansea, aged 83. In his early years he was associated with his father, Mr. Henry Jones, at the Neath Abbey engineering works—a concern which built steamers, railway bridges, and mill engines. When that enterprise ceased, father and son were connected with a foundry at Neath, and then, until his retirement about 25 years ago, the latter was associated with the Duffryn Tinplate Works, Morriston.

IT IS WITH DEEP REGRET that we announce the sudden death, at his home, 46, Dean Lane, Newton Heath, at the age of 64, of Mr. R. A. Miles, the Manchester and district representative of the Stanton Ironworks Company, Limited. Throughout the Lancashire area, Miles—almost universally known as "Dick"—was a particularly popular figure. He was originally trained as a moulder, but later passed on to the commercial side where his practical knowledge and genial personality won him a host of friends in the foundry industry. He joined the Institute of British Foundrymen in 1916 and was President of the Lancashire Branch in 1923-25. During his presidency he innovated the practice of asking ladies to participate in the social functions of the Branch, and thereafter retained the unofficial position of social secretary to the Branch. During his association with the Institute, Miles served on the General Council for long periods, and on most of its important committees. His sterling work for the Lancashire Branch will long be remembered, and his passing leaves a gap which will be difficult to fill. To Mrs. Miles and the family we tender our sincere condolences.

Forthcoming Events

FEBRUARY 18.

Institute of Metals (Birmingham Section):—"Metals and Foodstuffs." Paper by L. H. Lampett, in Birmingham, at 6.30 p.m.

FEBRUARY 21.

Institution of Mechanical Engineers:—"Mechanical Requirements of the Royal National Lifeboat Institution." Paper by Lt.-Col. P. H. Johnson, in London.

Institute of British Foundrymen

FEBRUARY 22.

East Midlands Branch:—"Permanent Moulds and Their Application in Non-Ferrous Alloy Production." Paper by F. Hudson, at Derby.

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Further information will be sent on request.

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Raw Material Markets

Consumption of foundry pig-iron continues to expand as a result of increased activity among light-castings makers, many of whom are securing quite a considerable amount of work for Government departments. In a number of instances manufacturers of small castings have rearranged their production to meet Government requirements. Plentiful supplies of foundry iron are being delivered. Heavy engineers, who use only a comparatively small tonnage of high-phosphorus iron, are substantial consumers of low-phosphorus iron and hematite, and these grades, being produced from imported ores, are, generally speaking, available only to priority consumers. A certain amount of iron of these qualities is being imported, as the demand outstrips home production.

Pig-Iron

MIDDLESBROUGH—With ironworks in this district concentrating on the production of basic and hematite iron, foundrymen continue to obtain their requirements from the Midlands. This is a quite satisfactory arrangement and adequate tonnages are being despatched. Light-castings makers in the Cleveland area are still open to accept fresh business, although many of them are doing a certain amount of Government work and are better placed than they were. Iron for the steelworks is in insistent demand and no abatement is envisaged for a long time to come. The hematite position remains tight, with supplies being released only for work of national importance. In all cases where mixtures can be rearranged so as to reduce the pressure on hematite this will have to be done in the future. In addition to home-produced hematite the Control have considerable tonnages of American iron available for distribution, but in view of the transport involved in acquiring this material and the high costs incurred, only high-priority users are being supplied with hematite from the United States.

LANCASHIRE—While most consumers of foundry iron have little complaint to make regarding deliveries, there is some delay experienced at times in obtaining supplies from Derbyshire and Northamptonshire producers, many of whom have quite a substantial accumulation of orders. Speciality engineering concerns, of course, continue to be fully engaged on contracts placed by various Government departments, and consumption of iron among these establishments is maintained at a high level. The position of the light-castings industry as a whole tends further to improve, but the volume of "war" work given out to concerns in this trade is still restricted. Jobbing foundries are moderately employed, but some of them have been handicapped owing to insufficient hematite having been delivered, and they are not always able to make use of refined iron, which is in freer supply.

MIDLANDS—Stocks of high-phosphorus iron are beginning to arise at many consuming points, and this concession on the part of the Control authorities has resulted in an increase in the demand for this material. Moreover, light-castings makers are using additional tonnages, as order-books in this section are in a healthier state than they were a few months ago, when there was little in the way of Government work available to these concerns. There has also been an expansion in the call for their products from builders' merchants, whose stocks have fallen to low levels. Northamptonshire and Derbyshire makers of foundry iron are able to despatch adequate supplies to consumers, and, apart from isolated instances of transport congestion, there are no delays reported in deliveries. Makers of heavy castings remain briskly employed, their outputs being mainly accounted for by Government departments. Machine-tool makers and other heavy engineering concerns are also very busy, and there is every indication that active conditions will continue for months to come. Low-phosphorus iron, hematite and refined iron constitute the main requirements of these works, although a comparatively small amount of high-phosphorus iron is used.

SCOTLAND—Local pig-iron users employed on important work have not been allowed to suffer through lack of supplies, although it has not been possible at times to meet their requirements from the outputs of producers in the United Kingdom, supplies of imported iron having been delivered to satisfy really essential demands. Heavy foundries are assured of a market for their products over several months ahead, while replacement orders appear to be available as and when required. There is still room for improvement among the light-castings section, however.

Coke

Despite the loss of many export outlets for foundry coke, the ovens are able to dispose of gratifying tonnages on inland account. Home consumption has increased considerably since the outbreak of the war, while many users have built up extensive stocks. Prices are controlled and are subject to revision at any time. For delivery to Birmingham and Black Country stations, the quotation for Durham best foundry coke is 61s. 6d. per ton.

Steel

War industries are being kept well supplied with the various descriptions of steel required and no essential demands are neglected. Licences for steel for other purposes, however, are issued with great reserve, as is indicated in the revision of the allocations to the tinplate trade. Steel imports have been at a high level in recent months, and the reduction recorded in December last was gratifying, although imports are still substantial. The Control authorities are confident that British steel output, together with supplementary supplies from the United States, will prove sufficient to cope with the abnormal demands now being made by wartime conditions.

Scrap

Demand for iron and steel scrap has shown signs of further advancement of late, especially for qualities suitable for consumption by the steelworks. The supply, on the whole, is satisfactory and large tonnages of fresh scrap are regularly being collected, including a substantial amount of salvage and demolition scrap. Most of the bigger consumers have stocks on hand and all users are eager to accumulate reserve supplies as a precautionary measure.

Metals

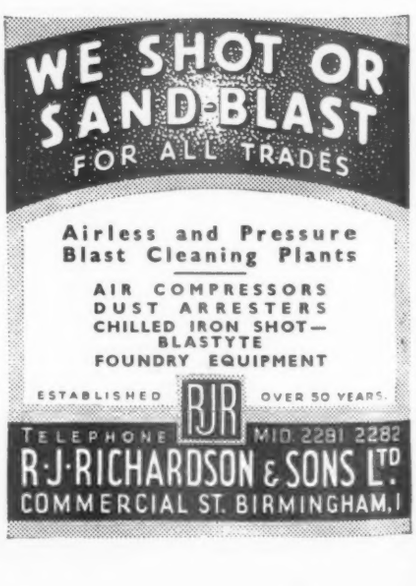
The Metals Reserve Company in New York is holding reserves of copper, but probably not over much, and issues are only being made when it can be clearly established that the would-be purchaser is in real need of the metal, having failed to place his order elsewhere. Later in the year, when supplies from South America begin to come in, the position will be easier, but for the moment the supply situation is rather tight, although the price stays at 12 cents delivered Valley. Customs smelters are for the most part obtaining a better price than this, with a premium of anything from 12½ to 50 points, but the authorities are not at all keen on seeing the quotation up above 12 cents. Export is listed at 10 to 37½ cents, f.a.s., and this may be regarded as the "official" price, but the whole situation as far as overseas business is concerned is now made more difficult by the fact that an export licence is necessary for copper and, for that matter, for brass, too. Domestic sales of copper in the United States in January were 104,251 short tons, against 89,517 tons in the previous month. American domestic copper consumers are being issued with a questionnaire by the Government to discover the probable rate of releases of copper from the Government stocks of imported metal.

Large tonnages of tin are being utilised in Government contracts, and consumption in the United Kingdom is at a high rate. The effect of the restriction of steel supplies to the tinplate makers will naturally tend to reduce the tin requirements of these concerns, but demand in other directions is likely to be fully sustained. While several peacetime outlets are now closed or restricted, many other uses for the metal have been found. For example, the production of military vehicles is on such a scale that it is unlikely that the absence of production of private cars for the home market is noticeable in the consumption figures of this particular industry. A firmer tone is noticeable in the American market, the spot price having moved up to 50.45 cents per lb.

The Statistical Bulletin of the Tin Research Institute (controlled by the International Tin Research and Development Council) estimates world production of tin in December last at 28,000 tons, bringing the total production for the year to 236,600 tons, compared with 184,300 tons in 1939 and 149,700 tons in 1938. United States deliveries totalled 115,497 tons in 1940, against 71,896 tons in the previous year and 50,660 tons in 1938. The 1940 deliveries, which include tin acquired for the emergency reserve stock, show an increase of nearly 61 per cent. over the deliveries for 1939. World stocks of tin, including smelters' stocks and carry-over, increased by 5,704 tons during December to 60,982 tons at the end of the year. Stocks at the end of 1939 were 50,407 tons.

Reviewing the tin industry in 1940 at the annual meeting of the British Tin Investment Corporation, Limited, in London last week, Lieut.-Col. S. H. Smith, who read the speech prepared by the chairman, Mr. Ernest V. Pearce, said the outstanding feature was the decision on the part of the American Government to purchase, as a reserve stock to be used in case of emergency, 75,000 tons of tin at not less than 50 cents per lb., or approximately £278 per ton. To provide this large tonnage it was necessary for the International Tin Committee to raise the quota of permissible exports from countries signatory to the International Tin Restriction Scheme to 130 per cent. of standard tonnages for one year from July 1, 1940. This quota was tantamount to unrestricted production. These factors appeared to justify a prediction that the tin-mining industry would continue to enjoy a considerable measure of prosperity during the immediate future. While the incidence of the 100 per cent. Excess Profits Tax operated harshly on all mining companies, it was a particular hardship on tin-mining companies whose known reserves of tin, constituting their capital assets, were limited and were wasting assets. With the international quota at 130 per cent. depletion of those assets was rapid, so that in effect Excess Profits Tax became a capital levy. Representations had been made to the authorities in this regard, and in fairness to shareholders it was hoped that some relief might be forthcoming in the shape of an allowance that would cover at least partially the depletion of ore reserves.

Tin prices on the London Metal Exchange during the past week have been as follow:—

Cash—Thursday, £256 10s. to £257; Friday, £256 5s. to £256 10s.; Monday, £256 15s. to £257; Tuesday, £257 to £257 5s.; Wednesday, £257 15s. to £258.

Three Months—Thursday, £258 to £258 5s.; Friday, £257 15s. to £258; Monday, £258 to £258 5s.; Tuesday, £258 5s. to £258 10s.; Wednesday, £258 to £258 5s.